BASINWIDE ASSESSMENT REPORT

WHITE OAK RIVER BASIN

NORTH CAROLINA
DEPARTMENT OF ENVIRONMENT AND
NATURAL RESOURCES
Division of Water Quality
Water Quality Section
Environmental Sciences Branch

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EXECUTIVE SUMMARY

This document presents a water quality assessment of the White Oak River basin. Information reported by outside researchers and other agencies is also presented. Division monitoring programs covered within this report include benthic macroinvertebrates, fish tissue, phytoplankton monitoring, ambient water quality, and aquatic toxicity for the period 1995 - 1999. Studies conducted prior to 1995 were previously summarized in NCDEHNR (1995).

The document is structured with physical, geographical, and water quality discussions given at the beginning of each subbasin section. General water quality conditions are presented in an upstream to downstream format. Subbasins within the basin are described by a six digit code (030501 – 030505), but are often referred to by their last two digits (e.g. Subbasin 01).

This river basin lies entirely within the southern, outer coastal plain, where 1,233 mi^2 of watershed drain into the New, White Oak, Newport, and North rivers (Figure 1). The basin contains 267 miles of freshwater streams and rivers. The basin also contains extensive estuarine areas in Bogue and Core sounds. There are about 192 mi^2 of saltwater in the basin.

The largest cities are Jacksonville on the New River and the Morehead City - Beaufort area on Bogue Sound and the Newport River. Richlands, Swansboro, Cape Carteret, Newport, Atlantic Beach, and Bogue Banks are other urban areas. Large portions of the basin are publicly owned areas such as the Croatan National Forest, the Hoffman State Forest, and the Cape Lookout National Seashore (Figure 2).

Figure 1. Location of subbasins in the White Oak River basin.

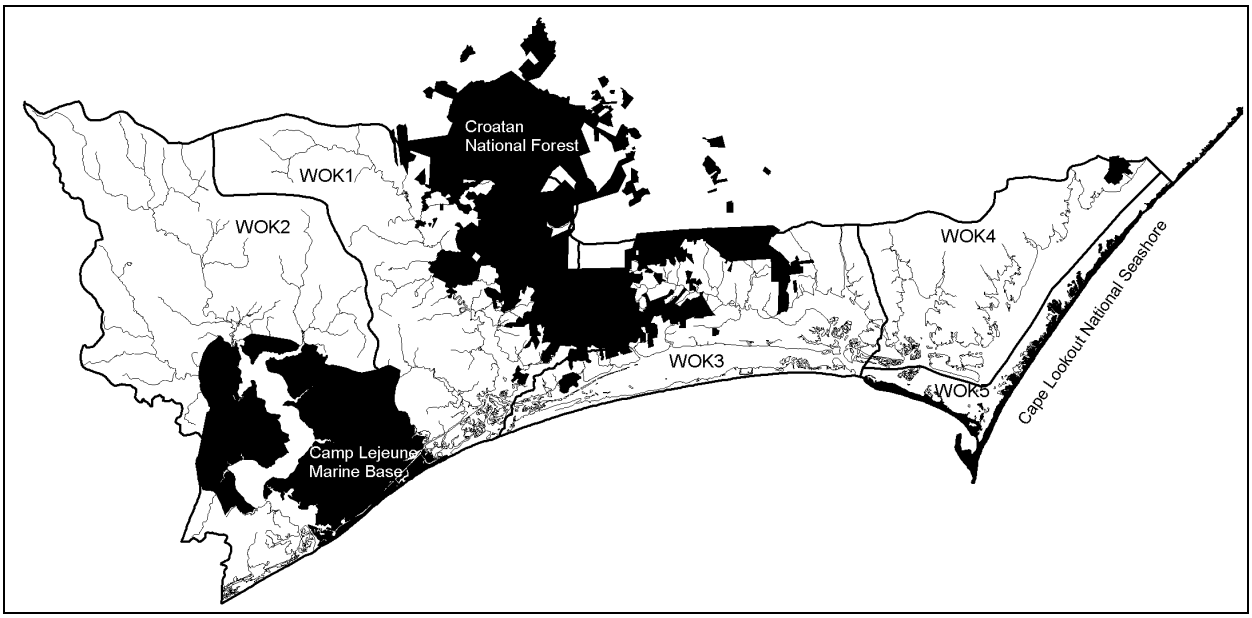

Figure 2. Federally owned lands in the White Oak River basin.

In the White Oak River basin, many waterbodies have been designated as Outstanding Resources Waters (ORW):

- Subbasin 01 -- the waters between Hammocks Beach State Park and the ICWW;
- Subbasin 02 -- Alligator Bay, Goose Bay, and a portion of the Intracoastal Waterway (ICW) south of the New River;
- Subbasin 03 -- the western half of Bogue Sound and the swamp and salt waters of the Theodore Roosevelt State Natural Area;
- Subbasin 04 -- most of Back Sound; and
- Subbasins 04 and 05 --Core Sound (except for a small area around the town of Atlantic (Figure 3).

Several waterbodies have also been designated as High Quality Waters (HQW) based upon their use as primary nursery areas. An example is in Subbasin 01 where a two mile section of the White Oak River, between Spring Branch and Hunters Creek is now supplementally classified as HQW.

The New River, in the southwestern portion of the basin, is a blackwater river whose watershed is located entirely within Onslow County. The watershed above the City of Jacksonville is characterized by gum-cypress swamps with upland areas used primarily for forestry and agriculture. The river is narrow, freshwater, and perennially flowing. At Jacksonville, near the US 17 bridge, the river widens, slows, and begins to exhibit estuarine influence until it discharges into the Atlantic Ocean. Land use in this lower section of the river is dominated by Jacksonville and the US Marine Corps' Camp Lejeune. In 1998, Jacksonville ceased its WWTP discharge to Wilson Bay and now land applies its waste. Camp Lejeune has also consolidated its discharges to an expanded (3 MGD) and upgraded Hadnot Point WWTP which has not failed a toxicity test since the upgrade.

The New River near Gum Branch, in the freshwater section, has been sampled for benthos since 1983. Bioclassifications were Good in the 1980s, but declined to Good-Fair in the 1990s. The cause for this continued decline is uncertain, because nitrogen and phosphorus levels, though still elevated, have declined in this portion of the river since 1996. Chronic algal blooms and fish kills have been documented in the main body of the New River below Jacksonville.

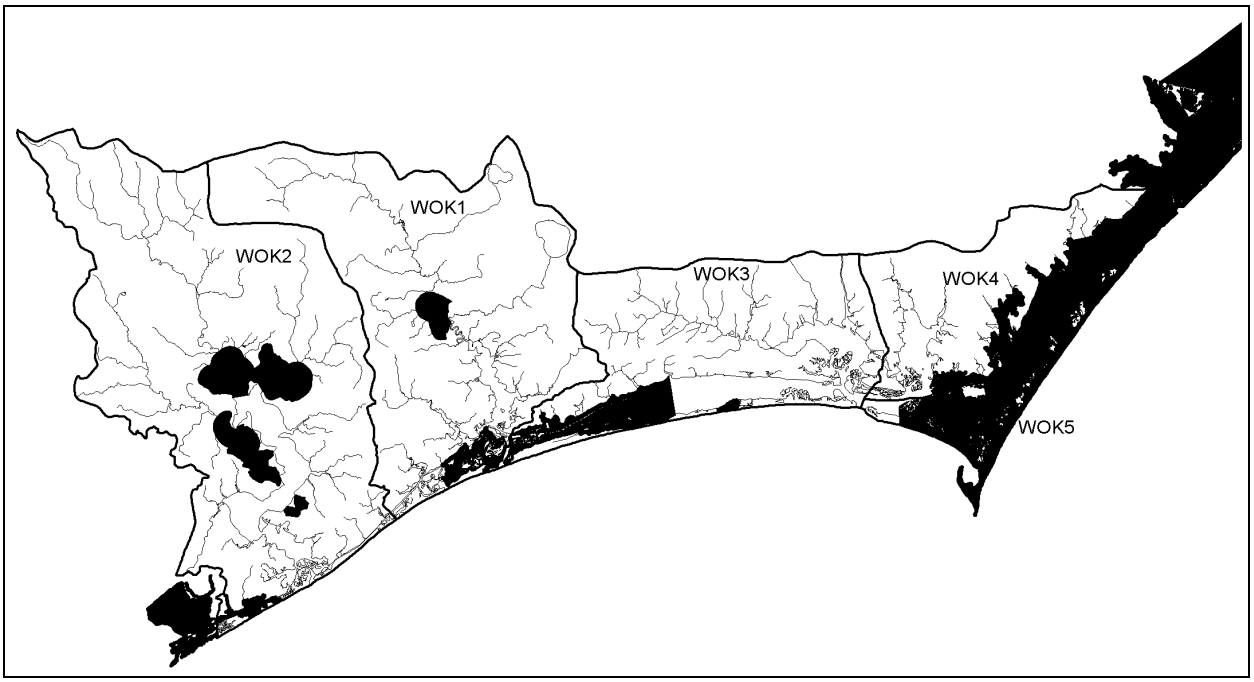

Figure 3. Outstanding Resource Waters and High Quality Waters in the White Oak River basin

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On June 21,1995, a dike collapsed on the 7.5 acre lagoon serving the Ocean View Farms Ltd near the Town of Richlands. Hog waste, estimated at 25 million gallons, was released into a tributary to the New River. In response, a special Division water quality study was conducted to determine the spills impact. The waste depleted dissolved oxygen in the river to levels lethal to fish for at least five days. But, the effects on the benthic community were minimal. Only a slight decline in EPT taxa and a slight increase in the Biotic Index were observed.

However, Burkholder *et al*. (1997) documented anoxia in a 29 km stretch of the river and 4,000 dead fish as a result of the same spill. The New River estuary from Jacksonville to Wallace Creek suffered algal blooms, reduced dissolved oxygen concentrations, and a smaller fish kill.

Investigators estimated the replacement cost of the fish at $2,700. Ocean View Farms was eventually assessed a $62,000 fine for penalty and investigative costs.

Most swampy tributaries to New River, Northeast Creek, Harris Creek and Southwest Creek, showed moderate signs of stress, while Little Northeast Creek appeared to be fairly natural in character. Only 3 of 26 largemouth bass collected from Northeast Creek and Brinson Creek had mercury levels greater than the US EPA screening level of 0.6 µg/g. All other fish species from sampled streams in the basin were below this concentration.

The White Oak River watershed is east of the New River. Much of the watershed lies within the Croatan National Forest and the Hoffman State Forest. Extensive pocosins dominate much of the landscape. Water quality is generally good in these areas. Streams flowing through these forests, including Holston Creek, Hunters Creek, and Pettiford Creek, have low pH, turbidity, and conductivity values. The west side of the river is more developed, so streams on this side, such as Starkeys Creek and Webb Creek, had higher pH and conductivity values and supported benthic communities more tolerant to pollution than streams on the east side of the river.

One ambient monitoring system site, on the freshwater portion of the White Oak River, had frequent fecal coliform bacteria

exceedences with elevated total suspended solids following rainfall events. This would suggest the continued effects of land disturbing activities, such as agriculture, logging, or development, in the watershed. Water quality in the mainstem seemed to be Good-Fair along most of its length, until tidal flushing caused improvement near Swansboro.

Bogue Sound is located in Carteret County, east of the White Oak River, between Bogue Banks and the mainland. Water quality seemed to be generally high here, although continued development along the mainland has led to the closure of several tidal creeks to shellfishing because of increased fecal coliform concentrations.

The Newport River widens into the Newport River estuary, which separates Bogue Sound from Back Sound and Morehead City from Beaufort. The head of the estuary, near Newport, has periodic, naturally low dissolved oxygen concentrations and low pH values due to swamp water inflow. The North and South Prongs of Newport River are swamp streams relatively unstressed by anthropogenic impacts. Moderate levels of impact were found in the river near Morehead City, probably from nonpoint sources. The most severe impacts to water quality were found in Calico Creek, which is the receiving waters for the Morehead City's WWTP.

The North River is east of Newport River and drains into Back Sound. Water quality is generally high in the sound, with low nutrients and bacteria concentrations and with ample dissolved oxygen. Most inland use is agricultural and farmed by Open Ground Farms. Coincidentally, upstream portions of the North River and Ward Creek were found to have frequently elevated bacteria concentrations. Taylors Creek is closed to shellfishing because of the presence of the City of Beaufort's WWTP outfall.

Core Sound is located northeast of Back Sound. Water quality was high through-out the sound and in many of the adjacent bays and creeks. Broad Creek was an exception, with frequently elevated bacteria concentrations, elevated nutrient concentrations, and sporadic low dissolved oxygen events. Runoff from agricultural areas seemed to be the problem.

EXECUTIVE SUMMARIES BY PROGRAM AREA

BENTHIC MACROINVERTEBRATES

Since 1983, 43 benthic macroinvertebrates samples have been collected from 28 freshwater sites and 98 samples have been collected from 41 estuarine sites in the White Oak River basin.

In 1999, 29 samples were collected – 15 from freshwater sites and 14 from estuarine sites. Only 2 of the 15 freshwater sites were rated. The New River at Gum Branch was rated Good from 1984 to 1988, then declined to Good-Fair since then. A site in the headwaters of the White Oak River was also rated Good-Fair.

The remaining 13 freshwater sites and all the estuarine sites were not rated. Swamp waters and estuaries, have presented problems in assessing water quality using existing methods. Estuarine biocriteria and swamp biocriteria are being evaluated for their ability to assess anthropogenic impacts.

Special studies which have been conducted specific to this river basin since 1994 include:

- Jacksonville WWTP's discharge removal,
- impacts from wastewater treatment plants, hog waste spills, and shopping center discharge; and
- community recovery with distance from a discharger.

Over the past several years, efforts have been made to develop biocriteria using estuarine macroinvertebrates. In the White Oak River basin, these efforts have included sampling at more than 23 sites. The purposes of these studies were:

- to determine if the estuarine methods were repeatable in areas of intermediate water quality and over a range of salinities and substrate types. In one particular study, salinities ranged from 10 to 27 ppt and substrates ranged from sand to sandy mud, with oysters, algae, and shells providing habitat at different sites (Biological Assessment Unit Memorandum B-971216; Eaton, in press);
- to determine if the methods were repeatable over time spans of 2 to 5 years. In another particular study, 12 sites were resampled a total of 20 times. Only the New River at Spring Point and the Newport River did not receive the same rating that they each did the first time they were sampled (90% repeatability) (Biological Assessment Unit Memorandum B-971216; Eaton, in press);
- sites in Back Sound, Jarrett Bay, and Core Sound were compared to collections made in nearby locations by the Environmental Monitoring and Assessment Program (EMAP) (Balthis et al. 1998). Water quality assessments using Division methods agreed with EMAP assessments of degradation 90% of the time. This was a higher rate of agreement than EMAP's own biological assessments (Eaton, in press); and

FISHERIES

Fish Community Structure

Approximately 52 species have been collected from the White Oak River basin (Menhinick 1991). Only one of these, the Atlantic sturgeon (*Acipenser oxyrhynchus)*, has been granted special status by the United States Department of the Interior, the North Carolina Wildlife Resources Commission, or the North Carolina Natural Heritage Program under the North Carolina State Endangered Species Act (G.S. 113-311 to 113-337 (LeGrand and Hall 1999; Menhinick and Braswell 1997). The species is considered rare or uncommon in the state and is listed as species of "Special Concern" (LeGrand and Hall 1999).

Fish Kills

The Division has systematically monitored and reported on fish kill events across the state since 1996. Field investigators reported 14 fish kill events in the White Oak River Basin from 1994 to 1999. Most events occurred in Subbasin 02 on the New River near Jacksonville.

During June 1995, a large kill of approximately 3,000 fish occurred from the headwaters of the New River to the US 17 bridge at Jacksonville. The kill occurred when a dike ruptured at the Ocean View Farms Ltd, near the Town of Richlands, spilling 25 million gallons of hog waste into the New River. The waste depleted dissolved oxygen to lethal levels in the river for at least five days. Investigators estimated the replacement cost of the fish at $2,700. Ocean View Farms was eventually assessed a $62,000 fine for penalty and investigative costs.

Other large kills on the New River often involved menhaden and were attributed to low dissolved oxygen concentrations and to diseases (NCDENR 1999a).

Fish Tissue

The DWQ collected fish tissue samples within the White Oak basin from July 1997 to April 1998.

Samples were collected from the New River, Northeast Creek, and Brinson Creek around the City of Jacksonville (Subbasin 02). These surveys were conducted after the results from a consultant working on Brinson Creek showed arsenic levels in pumpkinseed sunfish were greater than expected background concentrations, and mercury concentrations in largemouth bass and bowfin exceeded the state action level (Baker Environmental, Inc,1997). Division results showed mean concentrations of arsenic and mercury in all species from all sites were less than US EPA, US FDA, and state criteria. Additional analyses in three samples from Brinson Creek also showed non-detectable concentrations of pesticides.

Currently there are no basin-specific fish consumption advisories for the White Oak River basin. However, a statewide advisory is in place for bowfin. This species is found throughout the basin.

From August 1998 through August 1999, the Division of Marine Fisheries collected samples of king mackerel off the coast for mercury contaminant analysis. The samples were collected at the request of the Division of Epidemiology after health agencies in Texas and Florida recently issued consumption advisories for king mackerel due to potentially harmful levels of mercury.

Fish larger than 95 cm or 6.5 kg were found to have concentrations of mercury in excess of the North Carolina criteria of 1 µg/g. Based on these results, North Carolina, joined together with South Carolina, Georgia and Florida in March 2000 to issue a joint health advisory concerning high levels of mercury in large king mackerel. The advisory states:

- king mackerel less than 33 inches fork-length (from nose to where the tail forks) are safe to eat;
- king mackerel over 39 inches should not be eaten;
- people should limit their consumption of 33 to 39 inch fish:
  - women of child bearing age and children age 12 and younger should eat no more than one, 8-ounce portion a month; and
  - other adults should eat no more than four, 8-ounce portions a month.

The advisory does not prevent commercial fisherman or recreational anglers from landing king mackerel. Recreational anglers are allowed to land three fish/person/day with a minimum-size limit of 24-inch fork length. Federally permitted commercial fishermen are limited to 3,500 pounds/trip with a 24-inch fork length minimum size.

LAKE ASSESSMENT

No lakes were monitored by the Division in the White Oak River basin between 1994 and 1999.

PHYTOPLANKTON MONITORING

In response to the reorganization of wastewater treatment discharge along the New River in 1998, phytoplankton studies were initiated in 1997 and 1998. The latter study continues (as of May 2000).

Phytoplankton blooms were reported in each year on the New River from 1994-1999, and many of these blooms were associated with high chlorophyll *a* concentrations. Samples collected during fish kills in the New River during 1999 did not contain heterotrophic dinoflagellates which seemed to indicate that *Pfiesteria* was not present during these fish kills.

A few phytoplankton samples were collected in Subbasin 03 during suspected fish disease and fish kill events during 1997 - 1998 but these samples contained little or no amounts of *Pfiesteria*-like dinoflagellates.

In Subbasin 04, one algal bloom sample was collected in 1997 and three were collected in 1999. Only a sample collected from North River during July 1999 contained chlorophyll *a* concentrations exceeding the state chlorophyll standard of 40 µg/l.

AMBIENT MONITORING SYSTEM

There are 31 ambient water quality monitoring stations located in the White Oak River basin. These stations are sampled monthly for 27 parameters. Important findings during the recent (09/01/1994 to 08/31/1999) monitoring cycle included:

- No significant temporal patterns for most parameters among all the stations. One exception, was the monitoring station on the New River near Gum Branch. Decreases in nutrients and fecal coliform bacteria were observed at this site.
- Six stations with a high proportion of dissolved oxygen samples less than 5.0 mg/l were located in or near swampy areas.

- Extremely low concentrations of dissolved oxygen (approaching 0.0 mg/l) were observed just after Hurricanes Bonnie (July 1996) and Dennis (August 1999) at a few stations.
- Higher values for turbidity and total suspended solids were observed during periods of runoff.
- Copper exceeded the action level (7.0 µg/l for freshwater, 3.0 µg/l for saltwater) for more than 10% of the samples collected at 80% of the stations.

AQUATIC TOXICITY MONITORING

Four active facility permits in the White Oak River basin currently require whole effluent toxicity (WET) monitoring with a limit. The compliance rates of these four facilities, in recent years, have stabilized at approximately 95 - 100%.

The discharges located at the USMC Camp Lejeune base were consolidated into the Hadnot Pt. 002 outfall in October of 1998. Prior to then, some of the discharges experienced toxicity problems associated with excess total residual chlorine from the time they initiated monitoring in 1990 until mid-1992. Since consolidating the Camp Johnson, Hadnot Point 001, and the Tarawa Terrace discharges, the Hadnot Point 002 facility has been in compliance with its permit limits.

INTRODUCTION TO PROGRAM METHODS

The Division uses a basinwide approach to water quality management. Activities within the Division, including permitting, monitoring, modeling, nonpoint source assessments, and planning are coordinated and integrated for each of the 17 major river basins within the state. All basins are reassessed every five years, and the White Oak River basin was sampled by the Environmental Sciences Branch in 1994 and 1999.

The Environmental Sciences Branch collects a variety of biological, chemical, and physical data that can be used in a myriad of ways within the basinwide planning program. In some areas there may be adequate data from several program areas to allow a fairly comprehensive analysis of ecological integrity or water quality. In other areas, data may be limited to one program area, such as only benthic macroinvertebrate data or only fisheries data, with no other information available. Such data may or may not be adequate to provide a definitive assessment of water quality, but can provide general indications of water quality. The primary program areas from which data were drawn for this assessment of the White Oak River basin include benthic macroinvertebrates, fish tissue, phytoplankton monitoring, ambient monitoring, and aquatic toxicity monitoring.

BENTHIC MACROINVERTEBRATES

Benthic macroinvertebrates, or benthos, are organisms that live in and on the bottom substrates of rivers and streams. These organisms are primarily aquatic insect larvae. The use of benthos data has proven to be a reliable monitoring tool, as benthic macroinvertebrates are sensitive to subtle changes in water quality. Since many taxa in a community have life cycles of six months to one year, the effects of short term pollution (such as a spill) will generally not be overcome until the following generation appears. The benthic community also integrates the effects of a wide array of potential pollutant mixtures.

Sampling methods and criteria (Appendix B1) have been developed to assign bioclassifications ranging from Poor to Excellent to each benthic sample from flowing waters based on the number of taxa present in the intolerant groups Ephemeroptera, Plecoptera and Trichoptera (EPT S) (Appendix B1). Likewise, ratings can be assigned with a North Carolina Biotic Index (NCBI). This index summarizes tolerance data for all taxa in each collection. These bioclassifications primarily reflect the influence of chemical pollutants. The major physical pollutant, sediment, is not assessed as well by a taxa richness analysis. Different criteria have been developed for different ecoregions (mountains, piedmont, and coastal) within North Carolina for freshwater flowing waterbodies.

Bioclassifications listed in this report (Appendix B2) may differ from older reports because evaluation criteria have changed since 1983. Originally, total taxa richness and EPT taxa richness criteria were used, then just EPT taxa richness, and now BI as well as EPT taxa richness criteria are used for flowing freshwater sites. Refinements of the criteria continue to occur as more data are gathered.

FISHERIES

Fish Kills

Fish kills investigation protocols were established in 1996 by the Division to investigate, report, and track fish kill events throughout the state. Fish kill and fish health data collected by trained Division and other resource agency personnel are recorded on a standardized form and forwarded to the Environmental Sciences Branch where the data are reviewed.

Fish Tissue

Because fish spend their entire lives in the aquatic environment, they incorporate chemicals from this environment into their body tissues. Contamination of aquatic resources have been documented for heavy metals, pesticides, and other complex organic compounds. Once these contaminants reach surface waters, they may be available for bioaccumulation, either directly or through aquatic food webs, and may accumulate in fish and shellfish tissues. Results from fish tissue monitoring can serve as an important indicator of further contamination of sediments and surface water.

All fish samples were collected according to the DWQ's Standard Operating Procedures (NCDEHNR 1997). Analysis results are used as indicators for human health concerns, fish and wildlife health concerns, and the presence and concentrations of various chemicals in the ecosystem (Appendix FT1).

Fish kill investigation forms and supple-mental information are compiled in a database where the data can be managed and retrieved for use in reporting to concerned parties. Information on fish kills in other basins may be found on the Division's website (refer to the Glossary).

PHYTOPLANKTON MONITORING

An intensive monitoring study including phytoplankton (microalgae) was conducted in the New River (Subbasin 02) during 1986 - 1989 (NCDEHNR 1990). As a result, the New River was classified as Nutrient Sensitive Waters (NSW). Wilson Bay exhibited high concentrations of nutrients, chlorophyll *a*, and phytoplankton that were possibly attributable to the City of Jacksonville's WWTP discharge into Wilson Bay.

In March 1998, this effluent was converted to a non-discharge land application. In addition, the wastewater discharge from Camp Lejeune was consolidated into the French's Creek WWTP in November of that year. In order to gauge any environmental impacts from this restructuring, a preliminary phytoplankton monitoring study was conducted from June to December 1997. Another study on the river was begun during April 1998. The latter study was still in progress as of March 2000.

Phytoplankton samples were collected and analyzed in accordance with standard operating procedures (NCDEHNR 1992; NCDENR 1998n) (Appendix P1).

Pfiesteria and *Pfiesteria*-like dinoflagellates

The term "*Pfiesteria*-like dinoflagellate" refers to all cells which bear a cursory resemblance to the dinoflagellate *Pfiesteria piscicida* ("*Pfiesteria*") because multiple dinoflagellate species tend to look like *Pfiesteria*. Because it is difficult to discern *Pfiesteria* from other lookalike dinoflagellates under light microscopy, cell counts reported by the Ecosystems Unit personnel are only presumptive and include *all* cells that resemble *Pfiesteria*.

During late June 1999, the Ecosystems Unit obtained equipment necessary to view phytoplankton samples under epifluorescence microscopy (FM). This method excites chlorophyll under 397-563 nanometers of light. FM is used to discern photosynthetic dinoflagellates from heterotrophic dinoflagellates, but definitive identification of *Pfiesteria* requires the examination of its sub-membrane plate structure under electron microscopy.

Photosynthetic dinoflagellates always contain chloroplasts and glow throughout their cell when viewed under FM. *Pfiesteria*, on the other hand, does not contain its own chloroplasts. It instead relies on ingested algae, small aquatic invertebrates, and fish substances for nutrition. Therefore, *Pfiesteria* does not characteristically fluoresce unless it temporarily retains chloroplasts from algae it has ingested (Burkholder and Glasgow 1997, Burkholder *et al*. 1998).

Unpreserved samples collected from a fish disease/kill event are concentrated and examined under FM upon the day of their arrival at the Ecosystems Unit. In order to calculate total cell densities of all *Pfiesteria*-like dinoflagellates present in a sample, preserved aliquots are poured into a counting slide and settled overnight. These preserved aliquots are later examined under a light microscope without fluorescence. Any cell that visually resembles *Pfiesteria* is counted as a *Pfiesteria*-like dinoflagellate.

AMBIENT MONITORING SYSTEM

Assessments of water quality can be obtained from information about the biological communities present in a body of water or from field and laboratory measurements of particular water quality parameters. This section summarizes the field and laboratory measures of water quality, typically referred to as ambient water quality measures.

The Ambient Monitoring System is a network of stream, lake, and estuarine stations strategically located for the collection of physical and chemical water quality data. Parametric coverage is tiered by freshwater or saltwater waterbody classification and corresponding water quality standards. Under this arrangement, core parameters are based on Class C waters with additional parameters appended when justified (Table 1).

Table 1. Freshwater parametric coverage for the ambient monitoring system.[1]

Parameter	All freshwater	Water Supply
Field		
Dissolved oxygen	x	x
pH	x	x
Conductivity	✔	✔
Temperature	✔	✔
Nutrients		
Total phosphorus	✔	✔
Ammonia as N	✔	✔
Total Kjeldahl as N	✔	✔
Nitrate + nitrite as N	✔	x
Other		
Total suspended solids	✔	.
Total dissolved solids	.	x
Turbidity	x	x
Hardness	✔	x
Chloride	x	x
Bacteria		
Fecal coliform bacteria	x	x
Total coliform bacteria	.	x
Metals		
Aluminum	✔	✔
Arsenic	x	x
Cadmium	x	x
Chromium	x	x
Copper	x	x
Iron	x	x
Lead	x	x
Mercury	x	x
Nickel	x	x
Silver	x	x
Zinc	x	x
Manganese	.	x
Biological		
Chlorophyll *a*[2]	x	x

[1]A check (✔) indicates the parameter is collected; an 'x' indicates the parameter is collected and has a standard or action level.
[2]Chlorophyll *a* is collected in Nutrient Sensitive Waters (NSW).

Summaries of water quality parameters measured during the five year period (September 1, 1994 – August 31, 1999) are provided (refer to Tables 8 - 27). These tables present the number of samples collected and the number (and proportion) of samples greater than or less than a water quality reference value.

In addition, a description of how the data are distributed is provided using percentiles. Percentiles describe the proportion of observations less than a specific value or concentration. For example, the 50th percentile (also called the median) provides the value (or concentration) of the parameter in which one half (50%) of the observations lie.

The water quality reference value may be a narrative or numeric standard, or an action level as specified in the North Carolina Administrative Code 15A NCAC 2B .0200. Zinc is not included in the summaries for metals because recent (since April 1995) sampling or analyses may have been contaminated with zinc and the data may be unreliable.

Reporting levels for metals may vary depending on the salinity. Thus, some summary tables show all samples less than the reporting level and different values for the minimum and maximum observed. For example, the reporting level for nickel is 10.0 µg/l in freshwater and 50.0 µg/l in saltwater. As the salinity changes at a station so will the reporting level (see the values for nickel in Tables 10 and 11).

In this report, conductivity is synonymous with specific conductance. It is given in micromhos per centimeter (µmhos/cm) at 25 ^{o}C.

AQUATIC TOXICITY MONITORING

Acute and/or chronic toxicity tests are used to determine toxicity of discharges to sensitive aquatic species (usually fathead minnows or the water flea, *Ceriodaphnia dubia*). Results of these tests have been shown by several researchers to be predictive of discharge effects on receiving stream populations.

Many facilities are required to monitor whole effluent toxicity by their NPDES permit or by administrative letter. Facilities without monitoring requirements may have their effluents evaluated for toxicity by the Division's Aquatic Toxicology Laboratory. If toxicity is detected, the Division may include aquatic toxicity testing upon permit renewal.

The Aquatic Toxicology Unit maintains a compliance summary for all facilities required to perform tests and provides a monthly update of this information to regional offices and Division administration. Ambient toxicity tests can be used to evaluate stream water quality relative to other stream sites and/or a point source discharge.

WHITE OAK RIVER SUBBASIN 01

Description

This subbasin consists of the White Oak River and its tributaries in Onslow, Jones, Craven and Carteret counties (Figure 4). Most of this area, including its two lakes (Catfish Lake and Great Lake), lies within the U. S. Forest Service's Croatan National Forest and North Carolina's Hoffman State Forest and is relatively undisturbed.

A significant portion of waters in this subbasin are estuarine, including the waters around Hammocks Beach State Park, the Intracoastal Waterway, Bogue Sound, much of the White Oak River, and most of Queens Creek and Bear Creek.

With the exception of the Town of Maysville, most development is on the coast near the towns of Swansboro and Cape Carteret. There are nine NPDES permitted dischargers in this subbasin. None of them are required to monitor their effluent's toxicity. The largest discharger, Swansboro WWTP, discharges 0.3 MGD into Fosters Creek.

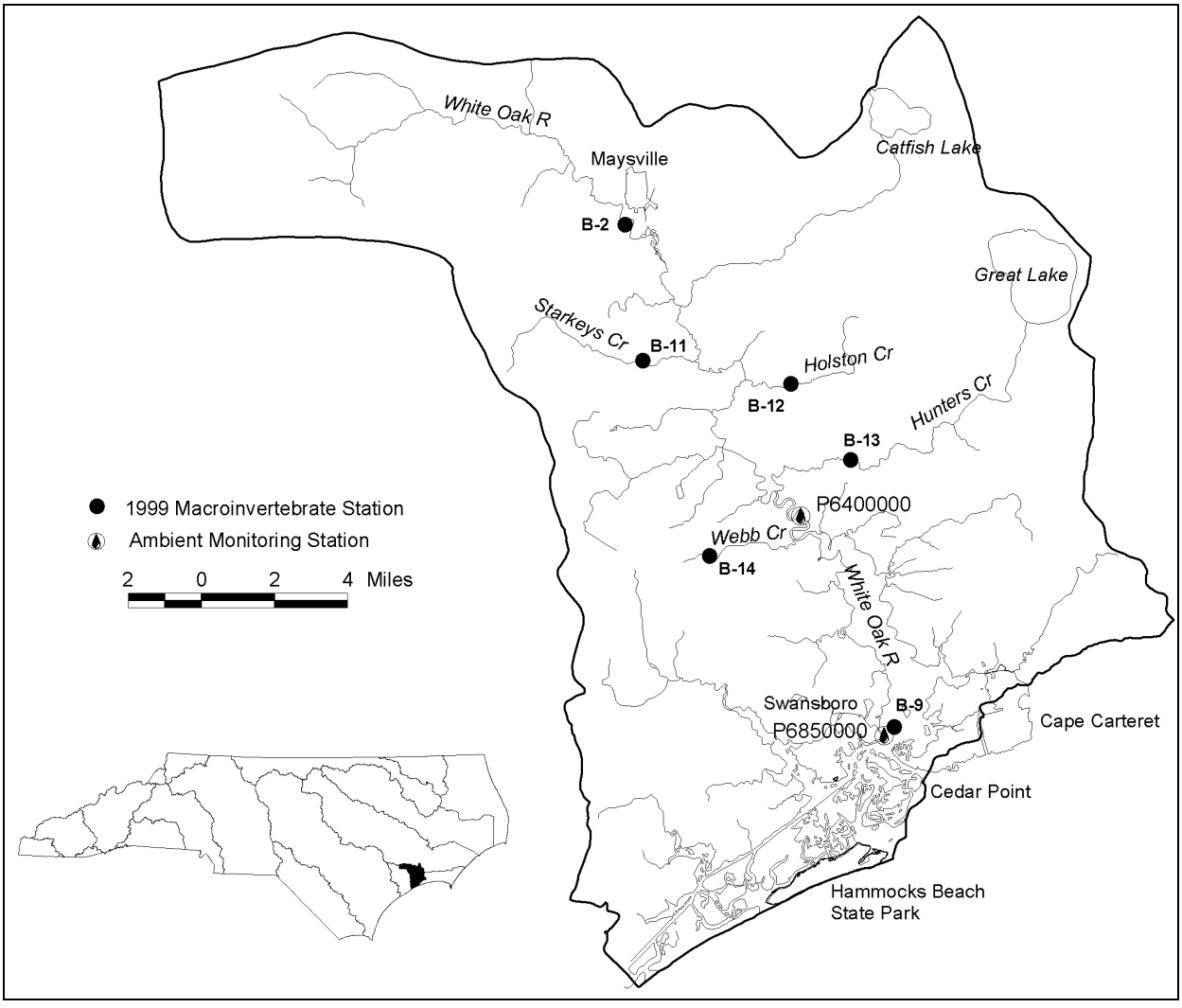

Figure 4. Sampling sites in Subbasin 01 of the White Oak River basin.

Overview of water quality

Supplemental water quality classifications have been given to several waterbodies in this subbasin:

- Nutrient Sensitive Waters -- the New River from its headwaters to Grey Point (half way between Jacksonville and the Atlantic Ocean);
- Outstanding Resource Waters -- the waters between Bear Island and Hammocks Beach State Park, plus the Intracoastal Waterway. The second, and largest area, extends from Bogue Inlet eastward, including all of Bogue Sound within this subbasin. This area includes Taylor Bay, but excludes all other creeks and bays; and
- High Quality Waters -- an approximately two mile stretch of the White Oak River between Spring Branch and Hunters Creek (Figure 3).

Because of the large number of ORW areas in this subbasin and the good tidal flushing, water quality in the sounds can be inferred to be generally high.

Benthic macroinvertebrate data were able to rate only one of the six streams monitored in this subbasin (Table 2). The White Oak River at US 17 in Onslow County was rated Good-Fair.

Table 2. Waterbodies monitored in Subbasin 01 in the White Oak River basin for basinwide assessment, 1994 - 1999.

Map #[1]	Waterbody	County	Location
B-2	White Oak R	Onslow	US 17
B-9	White Oak R	Carteret	near Swansboro
B-11	Starkeys Cr	Onslow	SR 1434
B-12	Holston Cr	Jones	NC 58
B-13	Hunters Cr	Carteret	SR 1100
B-14	Webb Cr	Onslow	SR 1432

[1]B = benthic macroinvertebrate monitoring sites.

Tributaries on the eastern side of the White Oak River, such as Holston Creek, Hunters Creek, and Pettiford Creeks, drain the Croatan National Forest. These streams were generally low in pH and undisturbed. Tributaries on the west side of the river were more heavily developed and showed greater impacts.

Ambient monitoring data were collected from two sites on the White Oak River. The water quality was generally good in the high salinity water at Swansboro with only sporadically elevated fecal coliform values (> 14 colonies/100ml). The White Oak River near Stella was a much more variable site, with wide variations in salinity (0 - 20 ppt). Frequent exceedences of the fecal coliform bacteria standard and elevated total suspended solids during periods of freshwater input suggested some effects from land disturbing activities in the area such as logging and construction.

The Division of Environmental Health's (DEH) Shellfish Sanitation Branch has reported that the Division of Marine Fisheries has prohibited shellfishing in 2,000 of the 18,900 acres of estuarine bottom in this subbasin. [Note: for the purpose of this report, prohibited waters are defined as permanently closed and provisionally closed. A summary of the DEH classifications will be reviewed and included in the use support decisions in the White Oak River basinwide water quality plan.] Prohibited areas included:

- the upper reaches of Bear Creek, and Queen Creek;
- Parrot Creek, Dick Creek, Hollands Mill Creek, Pettiford Bay, Fosters Creek (including the Intracoastal Waterway south of Swansboro), Broad Creek, and Gales Creek; and
- small areas around five marinas along the Intracoastal Waterway east of the White Oak River.

The Division of Marine Fisheries considered the commercial value of shellfish in this area to be Good; the oyster resource was rated Good-Fair (and primarily consumed locally), while the clam resource was rated Good and able to support a commercial fishery (NCDEHNR 1996a, 1996b; NCDENR 1998a, 1998b, 1999b, 1999c).

River and Stream Assessment

White Oak River, US 17

This site was located in a campground near Maysville where the stream was six meters wide. The substrate was a good mix of gravel, bridge rubble, and sand -- an uncommon combination in the usually sandy coastal plain. Snags and root mats also provided habitat.

The pH was high (7.1) for a tannin stained stream. This elevated reading was probably related to the large amount of photosynthesis occurring within the extensive mats of filamentous algae, which also indicated nutrient enrichment at this site. The low dissolved oxygen (DO) concentration (3.4 mg/l) recorded the morning the site was sampled

fit the pattern of large diel DO fluctuations and high pH due to excessive photosynthesis. The conductivity was also elevated (159 μmhos/cm) which also indicated anthropogenic inputs.

This site was not rated in February and rated Good-Fair in July (using Coastal A benthos criteria). While a large number of taxa were collected here, many abundant taxa were relatively tolerant to pollution (e.g. *Cheumatopsyche*, *Crictopus bicinctus*, *Conchapelopia, Dugesia tigrina* and *Laevapex fuscus*). Their abundance was reflected in the elevated Biotic Index (7.07).

White Oak River, near Swansboro

Substrate at this estuarine site, upstream of the NC 24 bridge, was mostly sand with occasional shells. These shells invariably supported a growth of the marine alga *Codium*. While the presence of more oysters in 1999 accounted for part of the difference in the taxa richness between years (Table 3), another component of the increased taxa richness and elevated Estuarine Biotic Index (EBI) seemed to be a relatively stable higher salinity in 1999.

Table 3. Summary of biological and physical data collected from the White Oak River near Swansboro, 1996 - 1999.

Date	Total S	EBI	Total S amphipods & caridean shrimp	Salinity (ppt)
02/27/1996	111	2.23	16	28
07/13/1999	145	2.66	26	31

Several marine taxa collected here in 1999, which have never been found in Division inshore collections before, included *Calappa angusta* (crab), *Anomia aculeata* (bivalve), and *Sigalion arenicola* (polychaete).

This phenomenon of more than the expected number of taxa being collected at an estuarine site was also observed at other sites in this basin (e.g. Bogue Sound, Newport River, and Calico Creek). This might have indicated that the increased numbers of stenohaline taxa might be related to the dry winter and spring during 1999. Low rainfall would have lead to reduced freshwater runoff and less variation in salinity.

Starkeys Creek, SR 1434

This six meter wide swamp stream, on the west side of the White Oak River, had a much higher pH (7.5) than the streams on the east side (pH from 4.0 - 4.6). While a large number of taxa were collected here (Total S = 93), the EPT N was depressed (41) and many taxa were tolerant to pollution.

This yielded a high Biotic Index (NCBI = 7.28) and suggested moderate stresses. About one-half of the watershed has been converted to agriculture, which may explain the elevated conductivity (110 μmhos/cm) and the rich growth of macrophytes.

Interesting taxa collected at this site included the caddisfly *Oecetis* sp. E (Floyd) and the dragonflies *Aeschna umbrosa* and *Gomphaeshna antilope*.

Holston Creek, NC 58

This eight meter wide stream was originally chosen as a reference site for developing swamp criteria (Refer to Special Studies section). However it also provided information on one of the major tributaries to the White Oak River. The headwaters of this stream are in the Croatan National Forest. The low conductivity (54 μmhos) and pH (4.6) suggested that there were minimal anthropogenic impacts.

The macroinvertebrate community was dominated by common swamp taxa: *Nyctiophylax moestus, Pycnopsyche, Stenonema modestum,* and *Leptophlebia*. Interesting taxa collected at this site included the caddisfly *Molanna blenda*, the midges *Uniella* and *Zalutschia*, and the water boatman *Hespercorixa brimley*.

Hunters Creek, SR 1100

Hunters Creek is the largest tributary to the White Oak River. The source of the creek is Great Lake in the Croatan National Forest. This sample was located approximately three miles above its confluence with the White Oak River. The main channel of the stream was five meters wide and usually over one meter deep. The substrate here, like most swamp streams, was a mix of sand and detritus with a good variety of pools and flow regimes. There was also a good variety of snags. The riparian zone was undisturbed at the area sampled. While not elevated for most tannin stained swamp streams, the pH (5.4) was greater than that at the other tributaries on the east side of the White Oak River (Holston Creek and Pettiford Creek).

This benthos was characteristic of a natural, undisturbed swamp stream. EPT abundance was high (EPT N = 62) and this was the only site in the basin where the stonefly *Taeniopteryx* was abundant.

Webb Creek, SR 1432
This sample was located near the headwaters of Webb Creek where the stream was only two meters wide. The stream appeared to be heavily impacted by local land use – a local home owner had replaced the riparian zone on the right bank with lawn turf. Consequently, the right bank was a badly eroding vertical drop. Because of this erosion, sediment had filled the pools in the stream and there was very little instream habitat. This site received the lowest habitat score in the White Oak basin (draft score = 38).

Because of the severe stress due to the lack of instream habitat, few taxa (Total S = 30) were collected here. And those that were found, tended to be pollution tolerant (NCBI = 7.34).

SPECIAL STUDY

Swamp Biocriteria Development
Pettiford Creek and Holston Creek were sampled as swamp reference sites. The purpose of the study was to develop and test biocriteria for swamp type streams (Biological Assessment Unit Memorandum B-990126).

OTHER SOURCES OF INFORMATION

A NOAA report summarized results from the EMAP estuaries sampling program in North Carolina from 1994 - 1996 (Balthis *et al*. 1998). One sample from this subbasin, Queens Creek, was collected in 1994. This site had a healthy benthic community with only tributyltin (an anti-fouling agent) found at elevated levels.

WHITE OAK RIVER SUBBASIN 02

Description

This subbasin is on the western end of the White Oak River basin and lies entirely within Onslow County (Figure 5). It contains the New River and its tributaries plus several small coastal streams. Nearly one-half of this subbasin is estuarine, with estuarine waters in the New River reaching upstream to Jacksonville and tidal fresh waters reaching nearly to Richlands.

Most of the development in this subbasin is on the New River: the Town of Richlands near the headwaters, the City of Jacksonville and the U. S. Marine Corps' Camp Lejeune in the middle reaches, and the Town of Sneads Ferry near the mouth.

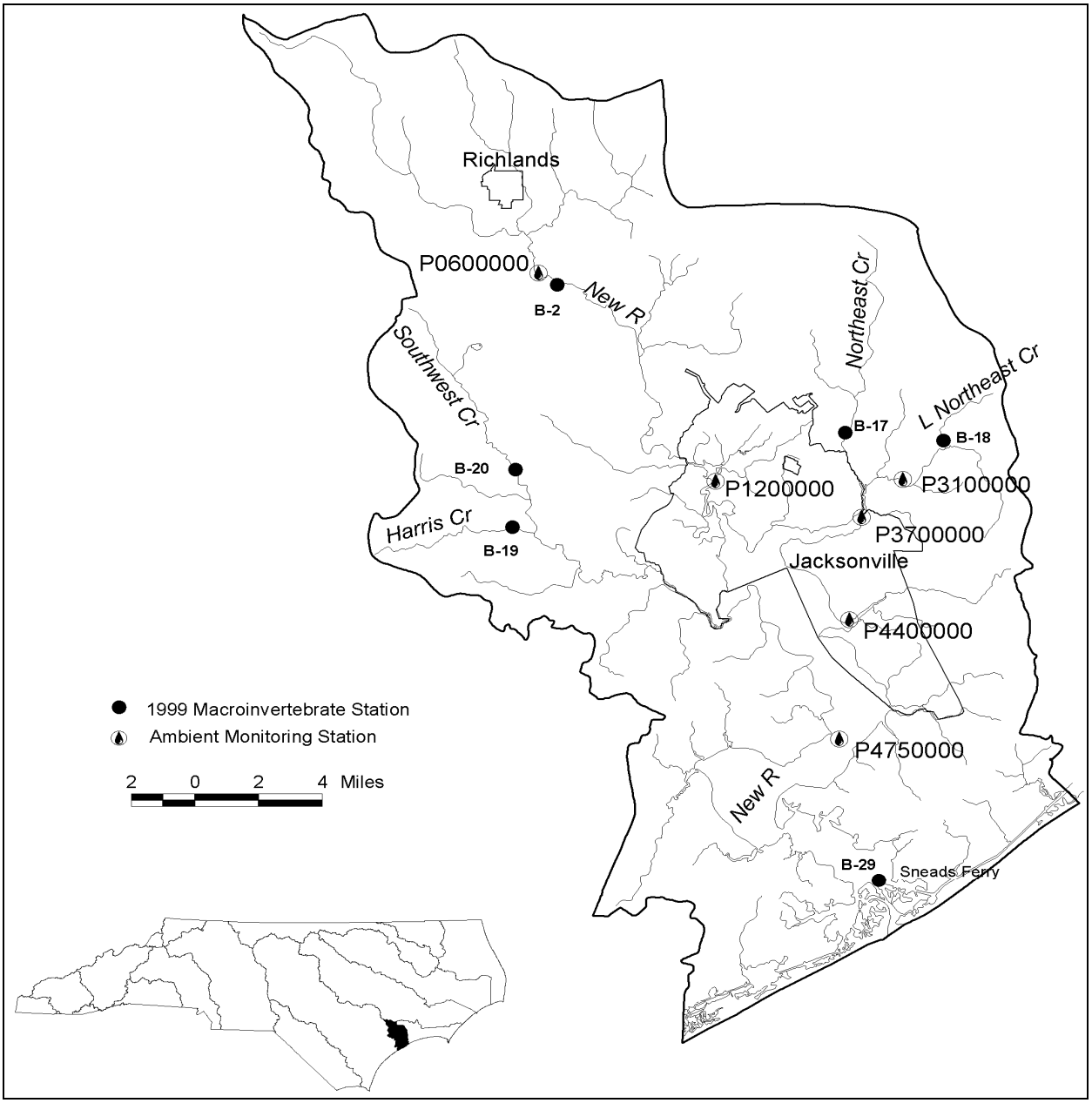

Figure 5. Sampling sites in Subbasin 02 of the White Oak River basin.

Three of the 32 permitted dischargers in this subbasin are considered major dischargers: Camp Lejeune USMC Hadnot Point and two small package plants. USMC Hadnot Point (New River) and ABC Cleaners (Northeast Creek) monitor their effluent for toxicity. The Jacksonville WWTP ceased discharge into Wilson Bay in March 1998 and now land applies their wastes. Four of the five facilities at Camp Lejeune ceased discharging in 1998. Wastes are now piped to the upgraded and expanded Hadnot Point facility, which now discharges closer to Frenchs Creek.

Overview of Water Quality

Supplemental water quality classifications have been given to several waterbodies in this subbasin:

- Outstanding Resource Waters -- Goose Bay, Alligator Bay and the portion of Intracoastal Waterway connecting them to the Cape Fear Basin;
- High Quality Waters (based on their use as primary nursery areas) -- New River from US 17 to Mumford Point (including Edwards Creek, Wilson Bay and Stick Creek), middle Northeast Creek and Scales Creek, lower Southwest Creek, Lewis Creek, Town Creek and Whitehurst Creek (Figure 3).

Benthic macroinvertebrate data were able to rate only one of the six streams monitored within this subbasin (Table 4). The New River at SR 1314 in Onslow County was rated Good-Fair.

Table 4. Waterbodies monitored in Subbasin 02 in the White Oak River basin for basinwide assessment, 1994 - 1999.

Map #[1]	Waterbody	County	Location
B-2[2]	New R	Onslow	SR 1314
B-17	Northeast Cr	Onslow	SR 1434
B-18	L Northeast Cr	Onslow	SR 1423
B-19	Harris Cr	Onslow	SR 1109
B-20	Southwest Cr	Onslow	SR 1213
B-29[2]	New R	Onslow	Sneads Ferry

[1]B = benthic macroinvertebrate monitoring sites.
[2]Data are available prior to 1994.

The water quality problems in this subbasin seemed to be indicative of the fact that this subbasin is the most heavily developed of any subbasin in the White Oak River basin. An exception to this trend was Wilson Bay, which has improved since the removal of the Jacksonville WWTP's effluent. However, algal blooms and fish kills seemed to be a chronic occurrence throughout the mainstem of the New River.

Tissue samples were collected from three sites in 1997 and 1998: Brinson Creek, the New River near Jacksonville and Northeast Creek. With the exception of two samples of largemouth bass from Northeast Creek and one sample from Brinson Creek, no samples had mercury concentrations greater than the US EPA criteria of 0.6 µg/g.

Ambient monitoring data were collected from six sites in this subbasin. Nutrient enrichment, particularly total phosphorus was a significant problem. The New River at Gum Branch also had elevated species of nitrogen (five year median NH_3 = 0.09 mg/l and NO_2+NO_3 = 1.25 mg/l). Concentrations of these two parameters have shown a small, but steady decline since 1990.

Periodic elevated fecal coliform bacteria concentrations also seemed to be a recurring problem in this subbasin. At Little Northeast Creek, the 1994 – 1999 median concentration of 140 colonies/100 ml, while still high, had decreased slightly from the period 1990 - 1994 (median value = 190 colonies/100 ml). Hypoxia, defined as a dissolved oxygen concentration < 1 mg/l, was also a sporadic problem for Little Northeast Creek.

The Division of Environmental Health's (DEH) Shellfish Sanitation Branch's most recent sanitary surveys reported that the Division of Marine Fisheries has prohibited shellfishing in 7,654 acres of the 20,325 acres of estuarine bottom it had surveyed in this subbasin. [Note: : for the purpose of this report, prohibited waters are defined as permanently closed and provisionally closed. A summary of the DEH classifications will be reviewed and included in the use support decisions in the White Oak River basinwide water quality plan.] Prohibited areas and the main reasons for the closures were:

- Development -- Gallion Bay and the Intracoastal Waterway from Onslow Beach west to Salliers Bay.
- Freshwater sources -- Mill Creek (Alligator Bay), Fullards Creek, Wheeler Creek, Fannie Creek, Everett Creek, Stones Creek, Muddy Creek, Mill Creek (New River), Town Creek, and the New River upstream of Town Creek;
- Effluent from WWTPs, and
- Marinas -- near the mouth of the New River.

Consolidation of discharges from Camp Lejeune resulted in the reopening of 125 acres near the old outfall in Stones Bay.

The Division of Marine Fisheries rated oyster and clam harvesting in this subbasin as Fair-Good with the best shellfishing in the New River from Ellis Cove to Farnell Bay. Overall the commercial value of the shellfish in this subbasin was rated Fair-Good (NCDEHNR 1996c; NCDENR 1998c, 1998d, 1999d).

River and Stream Assessment

New River, SR 1314
Benthic macroinvertebrates have been sampled seven times from the New River at Gum Branch since 1983. Bioclassifications were Good from 1984 to 1988. In 1990, there was a significant decline in water quality to Good-Fair. It was unclear whether this decline was from increased agricultural inputs in the watershed or from the Department of Transportation's widening of NC 24/258 and channelization of the New River approximately three miles upstream.

Sampling in 1995, following a 25 million gallon spill of hog waste, indicated that the site was only slightly more stressed than in 1990. This suggested that the waste had minimal additional impact beyond what the stream already experienced.

Data from 1999 showed a continuing decline in water quality (Figure 6) but a Good-Fair rating was retained. [Note: 1994 data were not collected at the usual site, but at a site more typical of outer coastal plain streams. Thus, 1994 data were not comparable to other collections and were not included in this analysis.]

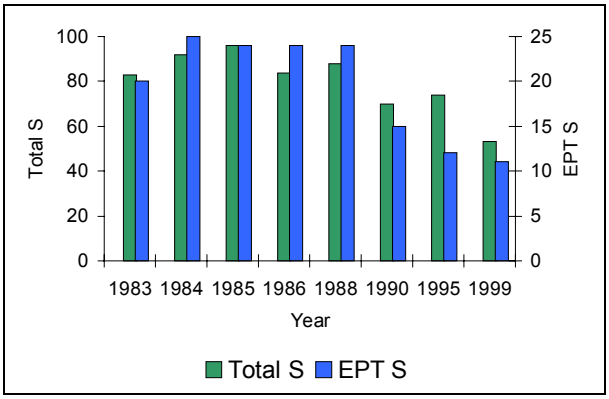

Figure 6. Total (Total S) and EPT (EPT S) taxa richness from the New River, SR 1314, Onslow County.

Northeast Creek, SR 1434
This site was located approximately half-way up the Northeast Creek watershed in suburban Jacksonville. The channel of the stream was eight meters wide with steep banks (indicating some channelization) and a slow to moderate current. The stream flowed throughout the summer, indicating this was not a swamp-type stream. Coastal A criteria could have been used on a summer collection, but Hurricane Dennis prevented sampling. This site was not rated in 1999.

Metrics for winter samples at this site and from the White Oak River at US 17, which also received a Good-Fair rating when it was sampled later in summer, were very similar.

Little Northeast Creek, SR 1423
This sample was located upstream from much of the suburban area of Jacksonville. The site was six meters wide when it was sampled in February. This stream supported a healthy stand of *Valisneria*, which in turn provided suitable habitat for a large number of shrimp and damselflies. The stream apparently had been snagged several years ago and there was a paucity of old wood to provide additional instream habitat. The conductivity was elevated (137 µmhos/cm), which could either indicate upstream inputs or salt water intrusion from downstream.

A high abundance of intolerant taxa (EPT N = 77) produced a low biotic Index (NCBI = 6.6) suggesting that stresses in this stream were natural.

Harris Creek, SR 1109
Harris Creek was sampled approximately one kilometer above it's confluence with Southwest Creek. While most of this stream appeared to be swamp-like, there was one constricted area that provided a riffle area when it was sampled in February. It was this constricted area that was still flowing in late summer and precluded using draft swamp criteria.

While the area surrounding the sampling site looked relatively undisturbed, there appeared to be more agriculture in the headwaters, which could explain the relatively high conductivity (151 µmhos/cm). The slightly elevated Biotic Index (NCBI = 7.13) also indicated some stress in the stream.

Southwest Creek, SR 1213
This eight meters wide stream was more than one meter deep in most locations within its confined channel. Flow was slow in the winter and non-

existent in summer. There were several breaks in the riparian zone near a potential source of nutrients and fecal coliform bacteria. Impacts suggested by the elevated conductivity (123 µmhos/cm) were reflected by the low number of intolerant taxa (EPT N = 41) and the consequently high Biotic Index (NCBI = 7.54).

The only EPT taxa that were abundant here were *Caenis* and *Eurylophella doris*. Their presence and the rareness of other EPT taxa may suggest moderate levels of stress.

New River, near Sneads Ferry

The New River near Sneads Ferry has been sampled 12 times since 1983. Salinity has been generally high at this site (range = 27 to 36 ppt); the exception being in October 1996, when there was still large volumes of fresh-water runoff two months after Hurricane Fran (salinity = 17 ppt).

Hurricane Fran had a demonstrable effect on the biota, causing a decline in benthic community diversity and abundance (Figure 7). The largest declines were in the soft-bodied taxa, such as polychaetes and shrimp (NCDEHNR 1997b). The community had recovered by 1999, just before the arrival of Hurricane Floyd.

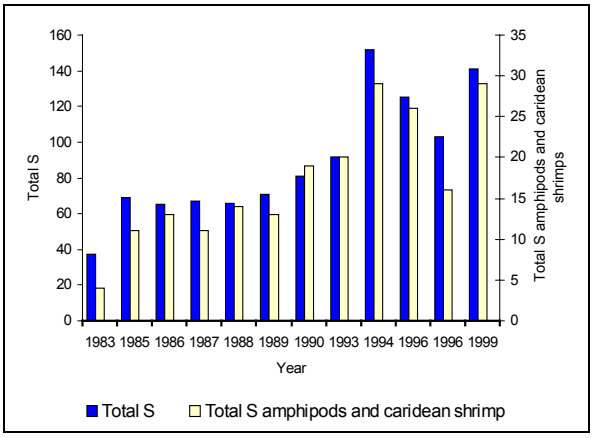

Figure 7. Total (Total S) taxa richness and total number of species of amphipods and caridean shrimp from the New River, near Sneads Ferry, Onslow County.

Taxa richness increased from 1983 until 1994. In 1994, taxa richness was the highest ever recorded for a North Carolina estuary . This was probably due to improved sampling techniques, because the Estuarine Biotic Index has remained stable since 1986 (Figure 8).

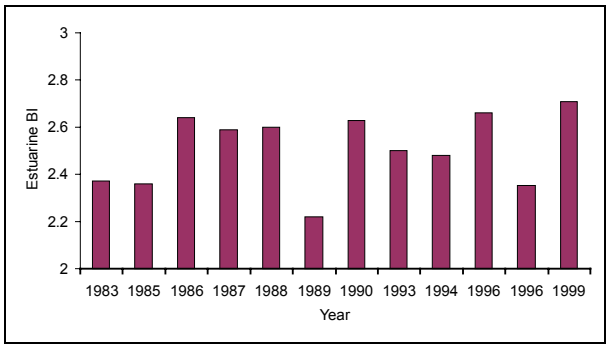

Figure 8. Estuarine Biotic Index from the New River, near Sneads Ferry, Onslow County.

SPECIAL STUDIES

WWTP Discharge Removal

Samples were collected before and after removal of dischargers into the New River. Water quality improved noticeably in Wilson Bay after removal of the City of Jacksonville WWTP's discharge. Taxa shifted from freshwater to estuarine species and taxa richness and abundance increased. Similar shifts were not noted upon the removal and re-siting of the USMC Camp Lejeune discharges (memorandum under review).

Impact from Blue Creek Utilities

Sites were sampled on Blue Creek above and below Blue Creek Utilities (NPDES Permit No. NC0056952) to determine if the discharge was impacting the stream. This 0.1 MGD plant has frequently been out of compliance. An increase in the abundance of pollution tolerant midges increased the NCBI at the downstream site, but not enough to cause the bioclassification to decrease from Fair (Biological Assessment Unit Memorandum B-970306).

Impact from a Hog Waste Spill

Two sites were collected on the New River to evaluate the effects of a 25 million gallon spill of hog waste. Only minor declines in the benthic invertebrate community in the New River were attributed to this spill (Biological Assessment Unit Memorandum B-950919).

Burkholder *et al*. (1997) however, documented anoxia in a 29 km stretch of the river and 4,000 dead fish as a result of the same spill. The New River estuary from Jacksonville to Wallace Creek suffered algal blooms, reduced dissolved oxygen concentrations, and a smaller fish kill.

Impact from a Shopping Center Discharge

Sites were sampled on UT Wallace Creek and a background site on Wallace Creek to assess

effects from the Piney Green Shopping Center (NPDES Permit No. NC0058874) discharge which had been found to be toxic. The discharge impacted the stream fauna and caused elevated deformity levels in the midge *Chironomus*. (Biological Assessment Unit Memorandum B-950606).

OTHER SOURCES OF INFORMATION

A NOAA report summarized results from the EMAP-Estuaries' sampling program in the North Carolina from 1994 – 1996 (Balthis *et al.* 1998). Two samples were collected from this subbasin: Alligator Bay (in 1994) and the lower New River (in 1996). Both sites had a healthy benthic community and neither site had elevated contaminant levels.

Fish Tissue

New River

Twenty -nine tissue samples were collected from the New River near Tar Landing during July 1997. All metal contaminant results were less than US EPA, US FDA, and state criteria (Appendices FT2 and FT3).

Northeast Creek

Nineteen tissue samples were collected from Northeast Creek above NC 24 near Jacksonville during April 1998. Mercury concentrations in 2 of the 10 largemouth bass samples exceeded the US EPA screening value of 0.6 µg/g (Appendix FT2). All other metal concentrations were less than state and federal criteria (Appendices FT2 and FT3).

Brinson Creek

Twenty-two tissue samples were collected from Brinson Creek near its mouth during April 1998. Only 1 of 16 mercury concentrations in largemouth bass exceeded the US EPA screening value of 0.6 µg/g (Appendix FT2). All other metals concentration were less than state and federal criteria (Appendix FT3). Three largemouth bass samples were also analyzed for pesticide contaminants. All concentrations were less than state and federal criteria.

Phytoplankton Monitoring

In March 1998, the effluent from the City of Jacksonville was converted to a non-discharge land application. In addition, the wastewater discharge from Camp Lejeune was consolidated into the Hadnot Point WWTP in October 1998. To gauge any environmental impacts from this restructuring, a preliminary phytoplankton monitoring study at seven sites was conducted from June to December 1997 (Figure 9). Another study was begun during April 1988. The latter study was still in progress as of June 2000.

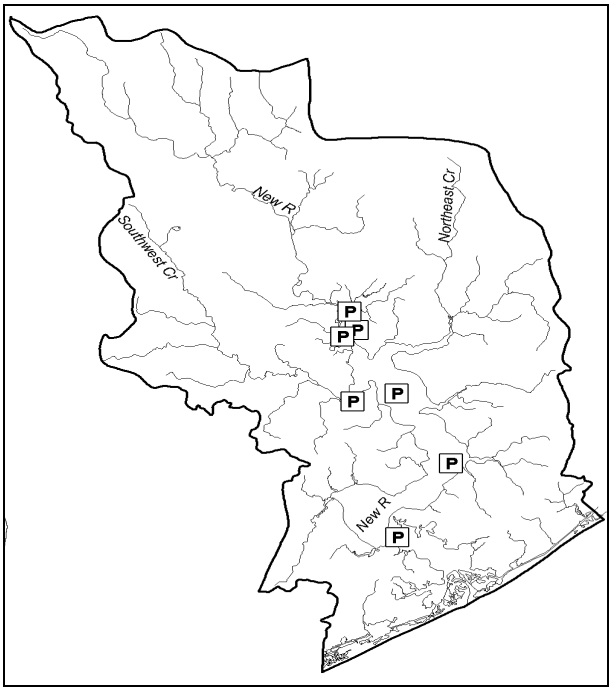

Figure 9. Phytoplankton monitoring sites in Subbasin 02 in the White Oak River basin.

Algal Blooms

1994
During early 1994, the New River experienced blooms of small centric diatoms (Bacillariophyceae) at Wallace Creek and near Jacksonville. The latter bloom was associated with high chlorophyll *a* (120 µg/l) which exceeded the standard of 40 µg/l.

Similar conditions were investigated near Jacksonville and at Wilson Bay during blooms of diatoms and the dinoflagellate *Gyrodinium aureolum* (Dinophyceae) in late June. Fish kills, which occurred with white, discolored water, were reported on several occasions. However, little algae were present in these samples.

1995
In April 1995, a bloom with high chlorophyll *a* (65 µg/l) in the New River near Jacksonville consisted of cryptomonads (Cryptophyceae), dinoflagellates, and small centric diatoms.

In late June, fish kills occurred in the New River near Jacksonville following a spill of swine waste from Ocean View Farm. Soon after this fish kill, bloom samples were collected just below Wilson Bay. These were blooms of dinoflagellates (*Gyrodinium uncatenum*, *Glenodinium danicum*, *Katodinium rotundatum*, and *Gymnodinium* sp.) and small centric diatoms, and the chlorophyll *a* concentration at Channel Marker 57 was 200 µg/l. In December, blooms with high chlorophyll *a* (120 - 130 µg/l) and composed of cryptomonads and dinoflagellates were reported near at Northeast Creek and Wallace Creek.

1996
During the spring of 1996, blooms with chlorophyll *a* concentrations of 65 - 180 µg/l near Jacksonville consisted of diatoms and dinoflagellates. In late July, fish kills with diatom and dinoflagellate blooms (chlorophyll 44-240 µg/l) were investigated at Wallace Creek and Grey Point. Early September fish kills accompanied additional blooms of diatoms and the dinoflagellate *Gyrodinium aureolum* at Wilson Bay, Northeast Creek, and Southwest Creek (chlorophyll *a* = 95 - 260 µg/l). These algal groups bloomed once again during late October at Grey Point and Marker 33, and the chlorophyll *a* concentration at Grey Point was 150 µg/l.

1997
The phytoplankton studies initiated in 1997 led to a greater number of reported blooms during 1997 - 1999. Blooms of diatoms, dinoflagellates, and cryptomonads were documented almost monthly from April through December 1997. These blooms occurred downstream from the US 17 bridge at Jacksonville to Southwest Creek, and many of these blooms produced high concentrations of chlorophyll *a*. Late December blooms were dominated by cryptomonads, and chlorophyll *a* levels at Wilson Bay and Northeast Creek were particularly high (160 - 270 µg/l).

1998
In 1998, intense blooms with high chlorophyll *a* (57 - 820 µg/l) occurred in Little Northeast Creek during late July and were dominated by an unidentified chrysophyte (Chrysophyceae). During a late August ambient monitoring system collection, one chrysophyte bloom with high chlorophyll (190 µg/l) was collected. Six blooms dominated by chrysophytes, cryptomonads, and greens (Chlorophyceae) were collected the following month, and the chlorophyll *a* concentration at Southwest Creek was 250 µg/l.

Dead fish were sighted in the mesohaline area of the river during late September and early October. Counts of *Pfiesteria*-like dinoflagellates conducted by Ecosystems Unit personnel were relatively low. The cause of these kill events was undetermined.

1999
Several algal blooms were documented in the New River between Jacksonville and French's Creek during ambient monitoring system collections conducted during April- December 1999. A bloom with high chlorophyll *a* (72 µg/l) of an unidentified chrysophyte was investigated at Wallace Creek in June. In November, different species were predominant in bloom samples collected at different sites and included green algae (Chlorophyceae), cryptomonads, diatoms, chrysophytes, and the dinoflagellate *Gyrodinium uncatenum* (chlorophyll *a* = 34 - 200 µg/l). In December, *G. uncatenum* blooms were investigated at four sites between Brinson Creek and Southwest Creek (chlorophyll *a* = 28 - 130 µg/l).

A large fish kill between Northeast Creek and Wallace Creek was investigated for a few days during late July 1999. All *Pfiesteria*-like cells examined under fluorescence microscopy appeared to be photosynthetic dinoflagellates (see earlier section on *Pfiesteria* and *Pfiesteria*-like dinoflagellates). Bycatch (the incidental capture of unmarketable or restricted commercial fishing species) was also suspected. A fish kill

presumably due to low dissolved oxygen was investigated the following month in Northeast Creek. Bloom samples collected at the site contained photosynthetic dinoflagellates and a large unidentified chrysophyte (chlorophyll *a* = 95 - 130 µg/l).

WHITE OAK RIVER SUBBASIN 03

Description

This subbasin lies in the center of Carteret County, extending from the U. S. Forest Service's Croatan National Forest to the Town of Beaufort and the Beaufort Inlet (Figure 10). Most of this subbasin is estuarine with the Newport River as the only major source of freshwater. With the exception of the Town of Newport, most of the development in this subbasin is along the coast and includes Morehead City, Beaufort, Atlantic Beach and Bogue Banks.

There are two major dischargers in this subbasin: the Newport WWTP (0.5 MGD) discharges to the Newport River and Morehead City's WWTP (3.4 MGD) discharges into Calico Creek.

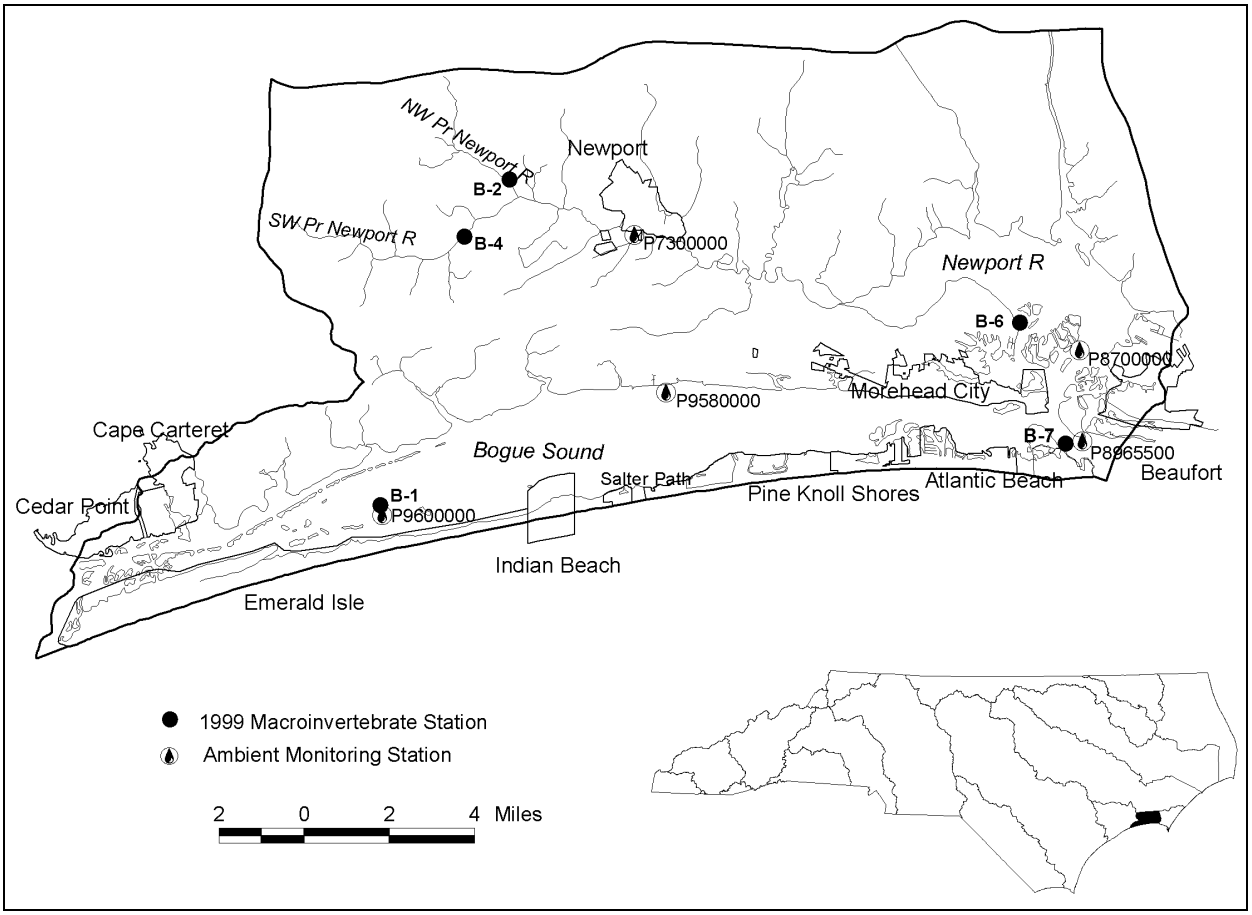

Figure 10. Sampling sites in Subbasin 03 of the White Oak River basin.

Overview of water quality

There are two Outstanding Resource Waters in this subbasin: the western half of Bogue Sound and the swamp and salt waters of the Theodore Roosevelt State Natural Area (Figure 3).

Benthic macroinvertebrate data from this subbasin were not used to assign ratings to any of the stream monitored (Table 5). Few algal blooms have been reported from this subbasin since 1994.

Table 5. Waterbodies monitored in Subbasin 03 in the White Oak River basin for basinwide assessment, 1994 - 1999.

Map #[1]	Waterbody	County	Location
B-1[2]	Bogue Sound	Carteret	Emerald Isle
B-2	NW Pr Newport R	Carteret	SR 1206
B-4	SW Pr Newport R	Carteret	SR 1124
B-6[2]	Newport R	Carteret	Crab Point
B-7[2]	Morehead Harbor	Carteret	Radio Island

[1]B = benthic macroinvertebrate monitoring sites.
[2]Data are available prior to 1994.

Ambient monitoring data were collected at five sites: one in the Morehead City Harbor, two in Bogue Sound, and two in the Newport River. Water quality was generally high in the estuarine portions of this subbasin. The Newport River at Newport had intermittent low dissolved oxygen concentrations and pH values which were probably the result of swamp flushing during high flows. This might have been the cause of the periodic elevated fecal coliform bacteria concentrations which were observed.

The Division of Environmental Health's (DEH) Shellfish Sanitation Branch most recent sanitary surveys reported that the Division of Marine Fisheries prohibited shellfishing in 3,749 acres of the 25,150 acres of estuarine bottom in this subbasin. [Note: for the purpose of this report, prohibited waters are defined as permanently closed and provisionally closed. A summary of the DEH classifications will be reviewed and included in the use support decisions in the White Oak River basin-wide water quality plan.] Prohibited areas and the three main reasons for the closures were:

- Development -- Salter Path, Pine Knoll Shores, Atlantic Beach, Morehead City, and Beaufort;
- Fecal coliform bacterial contamination in freshwater runoff -- Jumping Run, Spooner Creek, Wading Creek, Peletier Creek, Calico Creek, Gable Creek, Russell Creek, upper Harlowe Creek, and the upper Newport River; and
- Marinas -- shellfishing is prohibited around a number of marinas scattered throughout the subbasin.

In addition, there are approximately 1,200 acres that are conditionally approved to re-open. These areas are Core Creek, lower Harlowe Creek, and the northern shoreline of Bogue Sound from Gales Creek to Gull Harbor Marina (NCDENR 1998e, 1998f, 1999e, 1999f).

The Division of Marine Fisheries has classified waters in this subbasin to have Fair to Good commercial fisheries value. Oyster production was considered Fair, while clam production was considered Good. Newport River was found to be the most productive area for both clams and oysters.

River and Stream Assessment

Northwest Prong Newport River, SR 1206
This six meters wide swamp stream supported prolific growths of filamentous algae, suggesting there was some nutrient inputs from the watershed. Conductivity was elevated, 143 µmhos/cm, which also suggested some anthropogenic inputs. The nearby watershed was forested and the instream substrate was a mix of sand and detritus with a good variety of pools. The pH was low (4.1) and the water was tannin colored. By summer, though, the stream was no more than a series of two meter wide pools.

Taxa abundance was low; no mayflies or stoneflies were collected; and *Pycnopsyche* was the only abundant caddisfly. Low EPT N is characteristic of swamp sites with low pH. Good instream habitat, low NCBI and high chironomid taxa richness also suggested natural conditions.

Southwest Prong Newport River, SR 1124
This eight meters wide tannin-stained stream exhibited fluctuations in pH from its normal 4.2 to 4.7 when the sand mine, 100 m upstream, was pumping groundwater out of their pit. Other than the sand mine, the nearby catchment was forested.

The sand mine did not seem to be having a negative effect on the stream because the

conductivity (94 µmhos/cm) was less than that from the Northwest Prong Newport River and there were several EPT taxa that were abundant (*Stenonema modestum*, *Leptophlebia*, *Pycnopsyche,* and *Hydropsyche decalda*). Substrate in this stream was a mixture of sand and detritus with a good mix of snags, leaves and undercut banks to provide habitat.

This stream had stopped flowing and was turbid when revisited during the summer of 1999. However the turbidity extended above the sand mine, so the cause of the turbidity was unknown.

Bogue Sound, near Emerald Isle

Bogue Sound near Emerald Isle has been sampled 15 times since 1983. Habitats present at this location include seagrass (*Thalassia testudinum* and *Syringodium filiforme*), oysters, and muddy sand.

Salinity within this ORW area is high and stable (range = 29 - 38 ppt). This has led to a high number of total and intolerant taxa and a very stable and very high estuarine biotic index (Figures 11 and 12). Taxa richness increased from 1983 to 1991, probably as a result of improved sampling techniques. Taxa richness has remained stable since 1994 when a standardized collection technique was implemented.

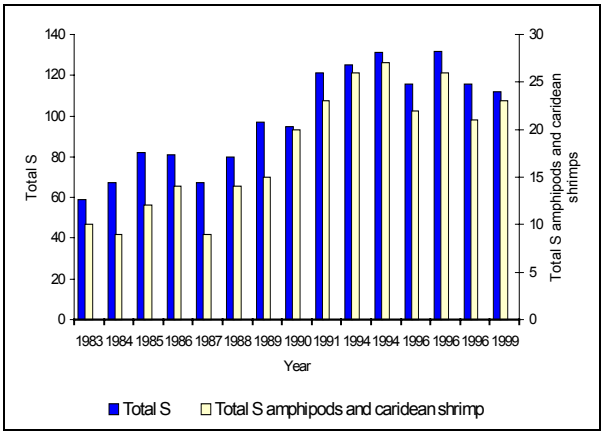

Figure 11. Total (Total S) taxa richness and total number of species of amphipods and caridean shrimp from Bogue Sound, near Emerald Isle, Carteret County.

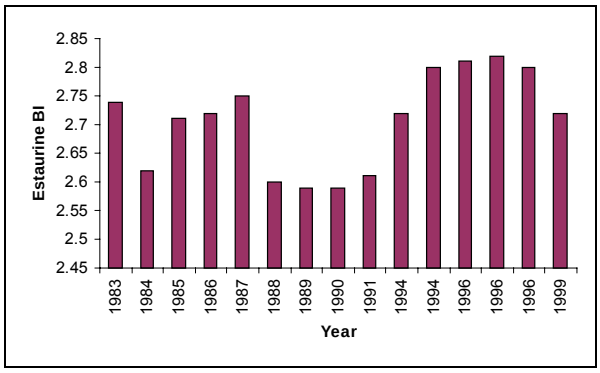

Figure 12. Estuarine Biotic Index from Bogue Sound, near Emerald Isle, Carteret County.

An undescribed species of amphipod, *Amphilochus* n. sp., has been collected here on every date sampled since 1994. Other rare taxa collected at this site include *Melanella intermedia* (snail), A*canthochitonia pygmaea* (chiton), *Mycale fibrexilis* (sponge*)*, *Mysidopsis mortensoni* (shrimp), and *Colomastix halichondrae* (amphipod).

Newport River, at Crab Point

Newport River near Crab Point has been sampled eight times since 1985. While salinity is usually high at this site (range = 21 - 35 ppt.), it fluctuates more than at the nearby reference site at Morehead Harbor (range = 29-36 ppt).

With the exception of a single metric (Estuarine BI in 1988), this site has demonstrated depressed biological metrics compared to Morehead Harbor in every year the two sites have been sampled (compare Figure 13 to Figure 15 and see also Figure 14). This indicated that this site was chronically stressed. It was not known how much of this stress was due to natural salinity fluctuations and habitat differences; or due to actual differences in water quality.

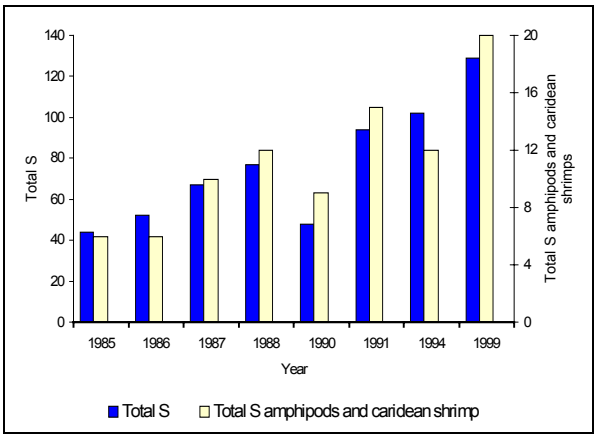

Figure 13. Total (Total S) taxa richness and total number of species of amphipods and caridean shrimp from the Newport River at Crab Point, Carteret County.

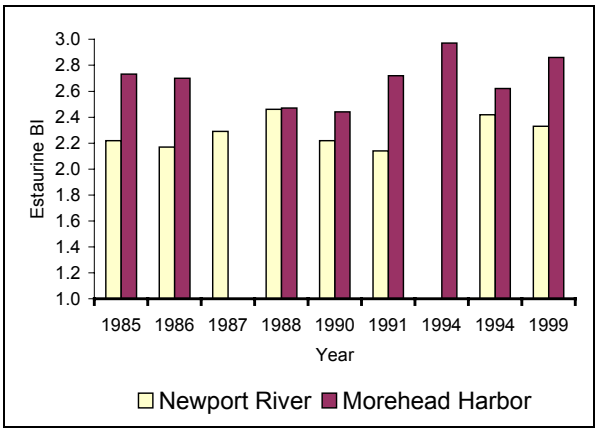

Figure 14. A comparison of the Estuarine Biotic Index from the Newport River at Crab Point and from Morehead Harbor, near Radio Island, Carteret County.

Taxa richness increases from 1985 to 1991 were probably a result of improved sampling techniques (Figure 13). The increase in taxa richness (Total S) between 1994 and 1999 was probably due to low freshwater inflow creating a higher, more stable salinity regime in the area which supported a more diverse community.

The Estuarine BI was slightly lower in 1999 than in 1994 (Figure 14) which suggested that the increase in Total S was not due to an improvement in water quality. Other sites in this basin (e g. the White Oak River above Swansboro) have exhibited the same phenomenon, indicating that this was an area-wide phenomenon and not site specific variability.

Morehead Harbor, near Radio Island

This site has been sampled eight times since 1985. The site has been characterized by a high, stable salinity (range = 29 - 36 ppt) and a variety of habitats.

Taxa richness has generally increased over time, probably as a result of improved sampling techniques (Figure 15).

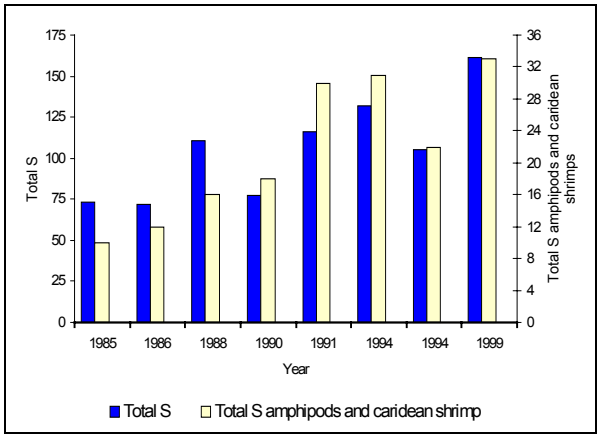

Figure 15. Total (Total S) taxa richness and total number of species of amphipods and caridean shrimp from the Morehead Harbor, near Radio Island, Carteret County.

There were, however, three exceptions to this trend. In 1990, sampling was not done at low tide, so the usual variety of habitats, especially rocks, was unavailable. The decline in all categories in August 1994 compared to June 1994 suggested that the spring abundance peak extends into June and thus, June samples should be compared with care to other summer samples.

The increase in taxa richness in 1999 seemed to be a system-wide change, as evidenced by similar taxa richness increases in the Newport River (Figure 13) and White Oak River (Table 3). These changes might have been due to low antecedent freshwater flows allowing a more diverse, stenohaline community to develop.

Taxa collected in 1999 that have been collected by the Division at three or fewer locations in North Carolina include *Astrangia* (coral), *Magelona* and *Eteone lactea* (polychaetes), *Epitonium rupicola* (snail), *Atylis urocarinatus* (amphipod), *Ancinus depressus* (isopod), *Tanais cavolini* (tanaid), and *Tanystyum orbiculare* (sea spider)

SPECIAL STUDIES

Determining the Impact of a Point Source Discharge in High Salinity Waters

In 1999, the Division's draft estuarine method was tested to determine if the method could be used to document recovery in the estuarine benthic community with movement away from a known point source discharge under high salinity water conditions. The known point source discharge was from Morehead City's WWTP in Calico Creek.

An improvement in water quality from near the outfall (Calico Creek at 20th Street) to the Newport River at Crab Point (2 km away) was documented. The Estuarine BI metric showed the most consistent improvement in water quality of any of the metrics with distance away from the discharge (Figure 16) (unpublished data).

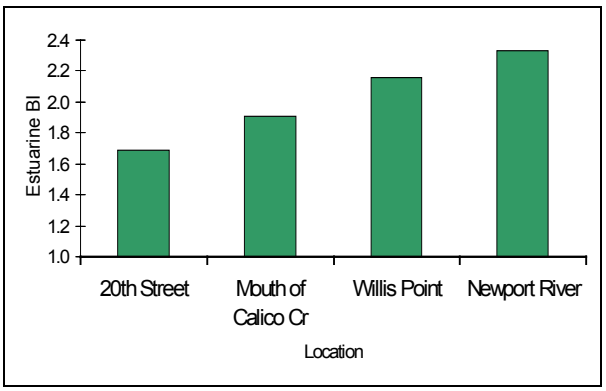

Figure 16. Relationship of the Estuarine Biotic Index to the distance way from a known point source discharge.

Swamp Biocriteria Development

The Southwest Prong Newport River was sampled in 1999 in the Croatan National Forest as a swamp reference site. This study developed and tested biocriteria for swamp sites. Four metrics were used (BI, EPT N, Total S, and Habitat) to develop a summary index. Corrections were developed for different pH ranges and stream channel types. (Biological Assessment Unit Memorandum B-990126).

OTHER SOURCES OF INFORMATION

A NOAA report summarized results from the EMAP-Estuaries' sampling program in the North Carolina from 1994 – 1996 (Balthis *et al.* 1998). Two sites were evaluated:

- The Newport River site in 1995 had a healthy benthic community and no contaminants were detected at elevated concentrations.
- Bogue Sound in 1996 also had a healthy benthic community. A toxicity test using the clam *Mercenaria mercenaria* found growth rates significantly different from the control, but no contaminants were detected at elevated concentrations.

Fish Tissue

From August 1998 through August 1999, the Division of Marine Fisheries collected samples of king mackerel off the coast for mercury contaminant analysis. The samples were collected at the request of the Division of Epidemiology after health agencies in Texas and Florida recently issued consumption advisories for king mackerel due to potentially harmful levels of mercury.

The samples which were collected quarterly showed concentrations of mercury increasing as the size of the fish increased. Fish larger than 95 cm or 6.5 kg were found to have concentrations of mercury in excess of the North Carolina criteria of 1 µg/g (Biological Assessment Unit Memorandum B-991208).

Based on those findings, North Carolina, joined together with South Carolina, Georgia and Florida in March 2000 to issue a joint health advisory concerning high levels of mercury in large king mackerel. The advisory states that king mackerel less than 33 inches fork-length (from nose to where the tail forks) are safe to eat, but king mackerel over 39 inches should not be eaten. People should limit their consumption of 33 to 39 inch fish; women of child bearing age and children age 12 and younger should eat no more than one 8-ounce portion a month; and other adults should eat no more than four 8-ounce portions a month.

The advisory does not prevent fishermen from landing fish larger than 39 inches. North Carolina recreational fishermen are allowed three fish per person per day with a minimum-size limit of 24-inch fork length. Federally permitted commercial fishermen are limited to 3,500 pounds per trip with a 24-inch fork length minimum size.

The advisory for king mackerel is North Carolina's first fish consumption advisory for ocean waters. The state began issuing mercury advisories for inland waters in the early 1990s. Mercury in large, long-lived fish is an international problem. Many states have issued advisories in the past decade. Research continues into the cause of the problem. Because high levels of mercury have been found in fish from relatively remote areas, researchers suspect that the mercury (which comes from industrial sources like coal-burning industries, chlorine manufacturing, waste incinerators as well as natural sources) is spread through the air, is deposited in water, and enters the aquatic food chain.

Algal Blooms

1994
A bloom of diatoms (Bacillariophyceae) was reported in Calico Creek in June 1994.

1995, 1996, 1999
No algal blooms were reported for these years.

1997
During late September and early October of 1997, phytoplankton samples were collected from Beaufort Inlet and Bogue Sound in conjunction with suspected fish disease/kill events. These samples contained little or no concentrations of *Pfiesteria*-like dinoflagellates.

1998
One dinoflagellate bloom in Green Pond was reported during a fish kill. The fish kill was attributed to improper herbicide use.

WHITE OAK RIVER SUBBASIN 04

Description

This subbasin lies to the east and north of the City of Beaufort in Carteret County (Figure 1). Major waterbodies in this subbasin include the North River, Jarrett Bay and Nelson Bay, plus the landward halves of Back Sound and Core Sound. Most of this subbasin is estuarine with freshwater drainage from adjacent land including Open Grounds Farm. The Town of Atlantic, at the northern end of the subbasin and Harkers Island at the south, are the two most densely developed areas within the subbasin. The two major dischargers in this subbasin are Beaufort Fisheries No. 2 (3 MGD) and Beaufort 's WWTP (1.5 MGD). Both facilities discharge into Taylors Creek.

Overview of water quality

Water quality seemed to be generally high in this subbasin. Large portions of this subbasin have been classified as Outstanding Resource Waters: Core Sound and most of Back Sound, Styron Bay, Brett Bay, Oyster Creek, Jarrett Bay, Willis Creek, Fulchers Creek, Maria Creek, Fork Creek, Ditch Creek, Broad Creek, Great Creek, Howland Creek, Jump Run, Tush Creek, and Great Marsh Creek (Figure 3).

No basinwide benthic invertebrate samples were collected in this subbasin from 1994 - 1999. In addition, there have been few reported algal blooms since 1994.

Ambient monitoring data were collected from seven sites: three which drained agricultural areas, three were at the mouths of the major rivers and bays, and one was near the Town of Atlantic. Generally, water quality seemed to be high in the high salinity portions of this subbasin, with low nutrient concentrations and adequate concentrations of dissolved oxygen. Three lower salinity sites drain agricultural areas and showed chronic fecal coliform bacteria violations (20% of the samples were elevated in the North River, 32% elevated in Ward Creek, and 85% elevated in Broad Creek). Broad Creek also had the highest concentrations of total phosphorus (median = 0.09 mg/l) and ammonia nitrogen (median = 0.07 mg/l) than any other sites in this subbasin. The site also had sporadic low dissolved oxygen events.

The Division of Environmental Health's (DEH) Shellfish Sanitation Branch most recent sanitary surveys reported that the Division of Marine Fisheries has prohibited shellfishing in 1,055 acres of the 38,700 acres of estuarine bottom in this subbasin. [Note: for the purpose of this report, prohibited waters are defined as permanently closed and provisionaly closed. A summary of the DEH classifications will be reviewed and included in the use support decisions in the White Oak River basinwide water quality plan.] Prohibited areas and the three main reasons for the closures were:

- Marinas -- especially around Harkers Island and Atlantic;
- WWTP effluents discharged into Taylors Creek; and
- Headwater areas of creeks and rivers -- North River, Middens Creek, Wade Creek, Williston Creek, Smyrna Creek, and Nelson Bay.

The Division of Marine Fisheries listed oyster production in this subbasin as Good to Fair and clam production as Good with an overall commercial value of Good (NCDENR 1998g, h, i, and j).

River and Stream Assessment

No sites were sampled in this subbasin since 1994. The single basin monitoring site in this subbasin, Ward Creek, was not sampled in 1999.

OTHER SOURCES OF INFORMATION

A NOAA report summarized results from the EMAP-Estuaries' sampling program in North Carolina from 1994 – 1996 (Balthis *et al.* 1998). Four sites were evaluated:

- Back Sound site had a healthy benthic community, however tributyltin concentrations (TBT, an anti-fouling agent) were elevated;
- Thorofare Bay had a healthy benthic community and no elevated contaminants;
- Jarrett Bay had a healthy benthic community, however a Microtox test indicated toxicity and elevated levels of Endrin and DDT were found; and
- Nelson Bay had a degraded benthic community. Elevated concentrations of arsenic and nickel were found and a toxicity

test using the clam *Mercenaria mercenaria* found growth rates significantly different from the control.

Algal Blooms

1994 - 1996, and 1998
No algal blooms were reported during these years.

1997
In August 1997, field personnel recorded elevated saturation of dissolved oxygen (118%) in Ward's Creek and suspected an algal bloom. Chlorophyll *a* concentrations were 9 µg/l -- well below the standard of 40 µg/l.

1999
In late July 1999, blooms of diatoms (Bacillariophyceae) and chrysophytes (Chrysophyceae) were reported in North River and Ward Creek, and chlorophyll concentrations at the former site were 59 µg/l. A bloom of euglenophytes (Euglenophyceae) was reported in Broad Creek later that November. No fish disease/kill events associated with algae were reported during this time period.

WHITE OAK RIVER SUBBASIN 05

Description

This subbasin includes the eastern side of Core Sound and the southern side of Back Sound in Carteret County (Figure 1). All of this subbasin is estuarine. The land within this subbasin, Shackleford Banks, Cape Lookout, and Core Banks, is part of the Cape Lookout National Seashore and is nearly undeveloped. The entire subbasin has been classified as Outstanding Resource Waters (Figure 3). There are no major dischargers in this subbasin.

Overview of water quality

Of the nearly 4,000 acres in Back Sounds in this subbasin, there are no areas closed to shellfishing. The Division of Environmental Health's Shellfish Sanitation Branch monitors bacteria at eight sites in this subbasin. From September 1993 through July 1998 there were only eight days where fecal coliform bacteria concentrations at any of the sites was greater than 7 colonies/100 ml. Because of the high quality water in this subbasin, there are no shellfish sanitation monitoring sites in the nearly 14,000 acres of Core Sound in this subbasin and all waters are open to shellfishing

The Division of Marine Fisheries classified the shellfish fishery in Back Sound as having Good commercial value, with oyster and clam production rated Good (DENR 1998k). The commercial value of Core Sound was Good to Excellent, with clam production rated Good to Excellent and oyster production rated Fair (DENR 1998l and m). The extensive grass beds of *Thalassia testudinum* and *Halodule wrightii* support the state's remaining scallop fishery.

River and Stream Assessment

No sites were sampled in this subbasin as part of the basinwide monitoring program.

OTHER SOURCES OF INFORMATION

A NOAA report summarized results from the EMAP-Estuaries' sampling program in the North Carolina from 1994 – 1996 (Balthis *et al* 1998). Two sites were evaluated:

- The Core Sound site had a healthy benthic community in 1994. However, tributyltin concentrations (TBT, an anti-fouling agent) were elevated.
- The Lookout Bight also had a healthy benthic community in 1996. However a toxicity test using the clam *Mercenaria mercenaria* found growth rates significantly different from the control.

AMBIENT MONITORING SYSTEM

The Division collects ambient water quality information from approximately 421 active monitoring stations statewide. In the White Oak River basin there are 31 stations (Table 6) of which 20 have been monitored for a sufficient period of time to determine if there have been any long-term changes in water quality (Figure 17).

For the purpose of this report, the basin has been divided into five drainages: the White Oak River, the New River, the Newport River, the North River, and coastal drainages. These five drainages corresponded to the five subbasins of the White Oak River Basin.

Box and whisker plots (Figures 18 - 27) were used to depict differences in the concentrations of values for various parameters among these 20 stations. Overall, no temporal patterns were noted except for the New River at Gum Branch. Line graphs showing concentrations of various parameters by year for Gum Branch show declines in ammonia as nitrogen, nitrate+nitrite nitrogen, and total phosphorus since 1996 (Figures 22 and 23).

Table 6. Ambient monitoring system sites within the White Oak River basin.

Subbasin-Drainage/ Station	Location	County	Class
02-New River			
P0600000	New R at SR 1314 near Gum Branch	Onslow	C, NSW
P1200000	New R at US 17 at Jacksonville	Onslow	SB, NSW
P3100000	Little Northeast Cr at SR 1406 near Jacksonville	Onslow	C, NSW
P3700000	Northeast Cr at NC 24 at Jacksonville	Onslow	SC, NSW
P4400000	Wallace Cr at R Dr at Camp Lejeune	Onslow	SB, NSW
P4750000	New R near Sneads Ferry	Onslow	SA
P2105000	Brinson Creek at mouth near Jacksonville	Onslow	SC, NSW
P2113000	New River at Wilson Bay at center point	Onslow	SC, HQW, NSW
P2210000	New River at channel marker G55 near Jacksonville	Onslow	SC, HQW, NSW
P4000000	Northeast Creek above Paradise Point near Jacksonville	Onslow	SC, NSW
P4075000	Southwest Creek at channel marker R2	Onslow	C, HQW, NSW
P4100000	Southwest Creek at the narrows	Onslow	C, HQW, NSW
P4200000	New River at channel marker G47 at Morgan Bay	Onslow	SC, NSW
P4570000	New River at channel marker G43 at Town Point	Onslow	SC, NSW
P4600000	New River upstream of Frenchs Creek	Onslow	SC, NSW
P4700000	New River at channel marker G37 near Grey Point	Onslow	SC, NSW
P9860000	Intracoastal Waterway at NC 210 at Goose Bay	Onslow	SA
01-White Oak			
P6400000	White Oak R near Stella	Onslow	SA
P6850000	White Oak R at Swansboro	Onslow	SA
03-Newport River			
P7300000	Newport R at SR 1247 at Newport	Carteret	C
P8700000	Newport R at channel marker G1 at Newport Marshes	Carteret	SA
P8965500	Morehead City Harbor at channel marker G15	Carteret	SA
P9580000	Bogue Sound at channel marker G15 near Salter Path	Carteret	SA
P9600000	Bogue Sound at Emerald Isle	Carteret	SA, ORW
04-North River			
P8975000	North R at US 70 near Bettie	Carteret	SA
P8976000	Ward Cr at US 70 near Otway	Carteret	SA
P8978000	Broad Cr at US 70 near Masontown	Carteret	SC
P8990000	North R at channel marker 56 near Beaufort	Carteret	SA
05-Coastal Drainage			
P9720000	Back Sound at channel marker G3 at Harkers Island	Carteret	SA, ORW
P9730000	Core Sound at channel marker R36 near Jarrett Bay	Carteret	SA, ORW
P9740000	Core Sound at channel marker G1 mouth of Nelson Bay	Carteret	SA

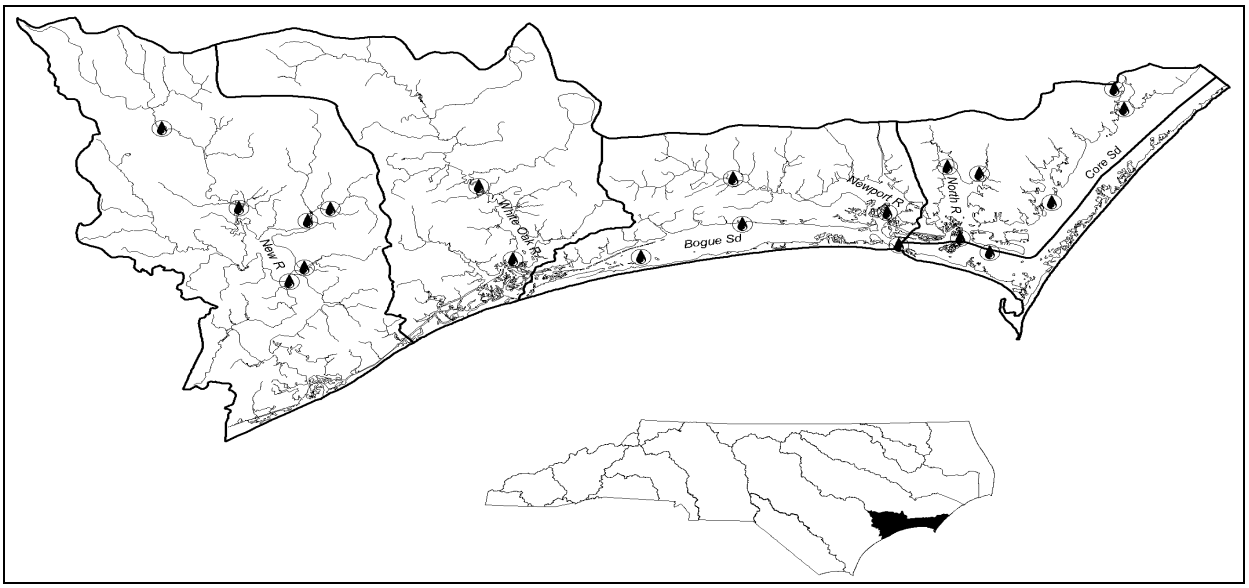

Figure 17. Ambient monitoring system sites within the White Oak River basin.

Fecal Coliform Bacteria

A summary of fecal coliform bacteria is provided (Table 7 and Figure 16). This table provides the number of samples collected, the number and proportion of samples greater than 200 and 400 colonies/100ml, and the geometric means for each station and for three time periods. These periods represent:

- the current basin assessment period (09/01/1994 to 08/31/1999),
- the five year period (09/01/1989 to 08/31/1994), and
- all data collected prior to 09/01/1989.

Overall, there were no significant differences in the geometric means among the three time periods at any station. The exception to this pattern was found at the New River near Gum Branch. Here the geometric mean and the proportion of samples exceeding 200 and 400 colonies/100ml have decreased over time (Table 7). However, the geometric mean has increased from 1989 to 1999.

Fecal coliform concentrations have increased slightly at Broad Creek (Table 7). Among stations located in streams classified as SA waters, the monitoring site along the White Oak River near Stella had the highest geometric mean (43.5) and 85% of the samples were greater than 14 colonies/100 ml (Table 7).

No station had a geometric mean greater than 200 colonies/100ml for the current assessment period (09/01/1994 to 08/31/1999). The stations with the highest mean were Little Northeast Creek and the Newport River at Newport (153 and 160 colonies/100ml, respectively).

An analysis was conducted to determine when three or more stations had fecal coliform bacteria concentrations ≥ 200 colonies/100ml. These dates were compared with flow in the New River at Gum Branch. For most cases, elevated concentrations corresponded to recent (within four days) or concurrent peaks in flow indicating recent precipitation and runoff. The greatest number of stations (six) that had elevated concentrations concurrently occurred on August 31, 1999. Concentrations ranged form 330 to 1,600 colonies/ml. Average daily flow increased from 87 cfs on August 26, 1999 to 2,100 cfs on August 28, 1999 as a result of Hurricane Dennis.

Table 7. Summary of fecal coliform bacteria collections from the White Oak River, 1968 - 1999.

Station (Class)	Sample dates First	Last	N	Number greater than 14	200	400	Percent greater than 14	200	400	Geometric Mean
New R. - Gum Branch (C NSW)	08/15/1969	08/22/1989	102	.	61	30	.	59.8	29.4	274.2
	10/03/1989	08/16/1994	13	.	3	2	.	23.1	15.4	55.6
	09/07/1994	**08/31/1999**	**63**	**.**	**8**	**5**	**.**	**12.7**	**7.9**	**85.1**
New R. - Jacksonville (SB NSW)	08/14/1969	08/29/1989	118	.	53	33	.	44.9	28.0	170
	10/26/1989	08/16/1994	42	.	4	1	.	9.5	2.4	37.0
	09/07/1994	**08/31/1999**	**66**	**.**	**16**	**7**	**.**	**24.2**	**10.6**	**60.7**
Little Northeast Cr. (C NSW)	08/14/1969	08/22/1989	30	.	13	9	.	43.3	30.0	192.6
	10/03/1989	08/16/1994	10	.	4	2	.	40.0	20.0	151.9
	09/07/1994	**08/31/1999**	**60**	**.**	**24**	**9**	**.**	**40.0**	**15.0**	**153.4**
Northeast Creek - Jacksonville (SC NSW)	08/14/1969	08/29/1989	94	.	33	31	.	35.1	33.0	144.5
	12/04/1989	08/16/1994	12	.	2	1	.	16.7	8.3	52.4
	09/07/1994	**08/31/1999**	**65**	**.**	**13**	**5**	**.**	**20.0**	**7.7**	**69.9**
Wallace Cr (SB NSW)	06/11/1986	08/29/1989	12	.	2	2	.	16.7	16.7	37.3
.	10/26/1989	08/16/1994	13	.	2	2	.	15.4	15.4	23.6
	09/07/1994	08/31/1999	59	.	7	3	.	11.9	5.1	28.0
New R. - Sneads Ferry (SA)	08/14/1969	08/29/1989	94	19	4	3	20.2	4.3	3.2	15.8
	10/26/1989	08/16/1994	44	2	0	0	4.5	0.0	0.0	10.6
	09/07/1994	**08/31/1999**	**56**	**3**	**0**	**0**	**5.4**	**0.0**	**0.0**	**10.7**
White Oak R. - Stella (SA)	08/14/1969	08/22/1989	74	52	9	6	70.3	12.2	8.1	50.9
	10/26/1989	08/16/1994	27	16	3	1	59.3	11.1	3.7	35.8
	09/07/1994	**08/26/1999**	**59**	**50**	**2**	**0**	**84.7**	**3.4**	**0.0**	**43.5**
White Oak R. - Swansboro	08/14/1969	10/30/1986	90	21	4	2	23.3	4.4	2.2	15.8
	07/15/1993	08/16/1994	12	0	0	0	0.0	0.0	0.0	10.0
	09/07/1994	**08/26/1999**	**57**	**9**	**0**	**0**	**15.8**	**0.0**	**0.0**	**11.0**
Newport R. - Newport (C)	08/15/1969	08/31/1989	115	.	26	19	.	22.6	16.5	112.7
	10/24/1989	08/11/1994	12	.	5	1	.	41.7	8.3	97.6
	09/28/1994	**08/31/1999**	**57**	**.**	**18**	**7**	**.**	**31.6**	**12.3**	**159.6**
Newport R. -Marshes (SA)	07/28/1993	08/29/1994	12	0	0	0	0.0	0.0	0.0	10.0
	09/27/1994	**07/22/1999**	**49**	**1**	**0**	**0**	**2.0**	**0.0**	**0.0**	**9.7**
Morehead City Harbor (SA)	07/28/1993	08/29/1994	12	1	0	0	8.3	0.0	0.0	11.8
	09/27/1994	**07/22/1999**	**49**	**1**	**0**	**0**	**2.0**	**0.0**	**0.0**	**9.9**
North R. - US 70 (SA)	03/04/1985	08/31/1989	18	1	0	0	5.6	0.0	0.0	10.6
	10/23/1989	08/11/1994	27	4	1	1	14.8	3.7	3.7	13.6
	09/28/1994	**08/26/1999**	**53**	**11**	**2**	**0**	**20.8**	**3.8**	**0.0**	**13.1**
Ward Cr (SA)	03/04/1985	08/30/1989	18	3	0	0	16.7	0.0	0.0	13.7
	10/23/1989	08/11/1994	26	7	3	0	26.9	11.5	0.0	20.0
	09/28/1994	**08/31/1999**	**57**	**18**	**1**	**1**	**31.6**	**1.8**	**1.8**	**17.0**
Broad Cr (SC)	030/4/1985	08/30/1989	16	.	3	1	.	18.8	6.3	56.0
	10/23/1989	08/11/1994	27	.	4	3	.	14.8	11.1	82.1
	09/28/1994	**08/26/1999**	**56**	**.**	**17**	**7**	**.**	**30.4**	**12.5**	**91.8**
North R. - Beaufort (SA)	06/25/1975	12/03/1984	29	4	1	1	13.8	3.4	3.4	14.0
	07/29/1993	08/29/1994	12	0	0	0	0.0	0.0	0.0	10.0
	09/27/1994	**07/22/1999**	**53**	**0**	**0**	**0**	**0.0**	**0.0**	**0.0**	**9.6**
Bogue Sound (SA)	06/25/1975	08/06/1980	34	17	0	0	50.0	0.0	0.0	24.4
	07/28/1993	08/29/1994	12	0	0	0	0.0	0.0	0.0	10.0
	09/27/1994	**07/22/1999**	**52**	**0**	**0**	**0**	**0.0**	**0.0**	**0.0**	**9.6**

Table 11. (continued).

Station (Class)	Sample dates First	Last	N	Number greater than 14	200	400	Percent greater than 14	200	400	Geometric Mean
Bogue Sound (SA ORW)	06/25/1975	10/29/1986	67	10	0	0	14.9	0.0	0.0	12.7
	07/28/1993	08/29/1994	12	0	0	0	0.0	0.0	0.0	10.0
	09/27/1994	**07/22/1999**	**43**	**3**	**2**	**1**	**7.0**	**4.7**	**2.3**	**11.4**
Back Sound (SA ORW)	07/29/1993	08/29/1994	12	0	0	0	0.0	0.0	0.0	10.0
	09/27/1994	**07/22/1999**	**49**	**0**	**0**	**0**	**0.0**	**0.0**	**0.0**	**9.5**
Core Sound - CM R '36' (SA ORW)	07/29/1993	08/29/1994	11	0	0	0	0.0	0.0	0.0	10.0
	09/27/1994	**07/22/1999**	**47**	**0**	**0**	**0**	**0.0**	**0.0**	**0.0**	**9.5**
Core Sound - Nelson (SA)	07/29/1993	08/29/1994	10	1	0	0	10.0	0.0	0.0	11.5
	09/27/1994	**07/22/1999**	**49**	**2**	**0**	**0**	**4.1**	**0.0**	**0.0**	**9.9**

[1]Row in bold face represents the summary for the current basin assessment period (09/01/1994 to 08/31/1999).
N = number of samples.

Dissolved Oxygen and pH

Six monitoring stations had dissolved oxygen (DO) concentrations less than 5.0 mg/l and four of these stations also had pH units below (or above) the standards for in more than 10% of the samples collected at the site (Tables 9 – 11, 14, 16, and 21; see Figures 19 and 20 where the 10th percentile on the box and whisker plots lies below appropriate reference line).

The majority of samples with DO < 5.0 mg/l were probably related to high temperatures. However 22% (of a total of 94 samples with DO < 5.0 ml/l) occurred when water temperatures were ≤ 19 ^{o}C. The lowest concentrations occurred concurrently among many stations in conjunction with hurricanes Bonnie in July 1996 and Dennis in August 1999.

The six stations with a high proportion of samples less than 5.0 mg/l are located in or near swampy areas or have low gradients. These conditions may influence dissolved oxygen concentrations and pH measurements.

Turbidity and Total Suspended Solids

No stations exceeded the standard for turbidity for more that 10% of the samples collected. However, the 95th percentile for the stations at Ward Creek and the North River (shown on Figure 14 as an open circle) indicated extreme values. A similar pattern could be seen for total suspended solids at the North River (Figure 15). High values for both turbidity and total suspended solids occurred on March 20, 1996, during a period of runoff which was indicative of non-point source runoff.

Nutrients

Overall, there were few spatial differences in the distributions of ammonia (NH_3) as nitrogen and total Kjeldahl nitrogen (Figures 24 and 25). However, spatial differences could be seen for nitrite + nitrate (NO_2+NO_3) as nitrogen and total phosphorus (Figures 26 and 27). The greatest concentrations and greatest variation for these nutrients occur at Broad Creek, Newport River, Northeast Creek, Little Northeast Creek, New River in Jacksonville, and the New River near Gum Branch.

The concentrations observed at the stations along Broad Creek and the Newport River might have been influenced by agricultural runoff. However the medians for nitrite + nitrate and total phosphorus should not be considered as elevated. Concentrations observed at Northeast Creek, Little Northeast Creek, and the New River in Jacksonville may be influenced by urban runoff. Finally, the concentrations observed in the New River at Gum Branch might have been the result of wastewater discharge upstream from Richlands. [Note: Nutrient concentrations have decreased recently at the New River near Gum Branch monitoring station (Figure 30).]

Chlorophyll *a*

The influence of decreasing water column nutrient concentrations in the New River drainage (Figure 30) has not been reflected in the phytoplanktonic community. There has been no significant decrease in chlorophyll *a* concentrations among the six sites over the past 15 years (Figure 28).

Though stations P3700000, P1200000, and P4400000, all in the vicinity of Jacksonville and Camp Lejeune, continued to experience

excursions above the 40 µg/l standard during the latter part of this five year review cycle, there was an apparent decrease in chlorophyll *a* concentrations. Exceedences now occur infrequently.

Metals

Copper commonly exceeded the action level (7.0 µg/l for freshwater and 3.0 µg/l for saltwater) for more than 10% of the samples collected. This occurred in 16 of the 20 stations monitored. Iron exceeded its action level (1000 µg/l) for more that 10% of samples collected (10.5%) only at the Little Northeast Creek monitoring station

Temporal Patterns

During this assessment period, a variety of measures were implemented by the cities of Richlands and Jacksonville, and the US Marines Corps to improve wastewater treatment and the water quality in the New River. The ambient monitoring data collected from sites located in the New River were examined to determine any temporal patterns. Changes in concentrations over time were noted for a variety of parameters collected from the New River monitoring station near Gum Branch (Figures 29 and 30).

The most obvious patterns were decreases in fecal coliform bacteria and all nutrients beginning during 1995 (Figures 29 and 30). Data collected from the monitoring sites located in Jacksonville and near Sneads Ferry were beginning to show improvements for a variety of parameters (total suspended solids, turbidity, and nutrients). However, not enough time has elapsed since implementing the improvements for wastewater treatment to substantiate the changes seen in the ambient water quality data.

Table 8. Summary of water quality parameters collected from the New River near Gum Branch (Station P0600000; Class C NSW) during the period 09/01/1994 to 08/31/1999.

Parameter	N	N < RL	Ref.	N > Ref.	% > Ref.	Min.	Max.	Percentiles 10	25	50	75	90
Field												
Temperature (^oC)	57	.	.	.	.	6	26	8	12	18	21	24
Conductivity	56	.	.	.	.	28	367	154	176	235	301	332
Dissolved Oxygen	56	.	5	4	7.1	2.8	11.8	5.6	6.2	7.2	8.9	10.4
pH (s.u.)	57	.	< 6; > 9	0	.	6.4	7.8	6.8	7.0	7.2	7.4	7.5
Other												
Total Residue	0	0	.	.	.	.	.	.	.	.	.	.
Total Sus. Solids	55	14	.	.	.	1	56	1	1	2	5	8
Hardness	57	0	.	.	.	50	34000	57	74	100	140	190
Chloride	2	0	.	.	.	13	3700	.	13	1857	3700	.
Turbidity (NTU)	59	0	50	0	.	1.4	12.0	2.3	3.0	3.7	4.8	7.7
Bacteria												
Total coliform	0	0	.	.		.	.	.	.	.	.	.
Fecal coliform	63	1	200	8	12.7	9	860	27	51	82	138	284
Nutrients												
NH_3 as N	63	6	.	.	.	0.01	2.00	0.01	0.03	0.09	0.14	0.25
TKN as N	64	0	.	.	.	0.1	4.0	0.2	0.3	0.4	0.5	0.7
NO_2+NO_3 as N	64	0	.	.	.	0.07	3.60	0.72	1.00	1.25	1.70	2.01
Total Phosphorus	64	0	.	.	.	0.02	0.60	0.06	0.08	0.11	0.16	0.21
Algal biomass												
Chl *a*	56	29	40	0	0	1.0	10	1.0	1.0	1.0	3.0	4.0
Metals (total)												
Arsenic	58	58	50	0	.	10	10	10	10	10	10	10
Cadmium	58	58	2	0	.	2	2	2	2	2	2	2
Chromium	58	58	50	0	.	25	125	25	25	25	25	25
Copper	58	35	7	4	6.9	2	20	2.0	2.0	2.0	3.0	5.8
Iron	58	0	1000	1	1.7	240	1200	363	420	560	730	877
Lead	58	58	25	0	.	10	50	10	10	10	10	10
Manganese	0	0	.	.	.	.	.	.	.	.	.	.
Nickel	58	58	88	0	.	10	10	10	10	10	10	10
Aluminum	58	1	.	.	.	50	1000	103	150	220	420	634
Mercury	58	58	0.012	N/A	.	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Abbreviations:

N	Total number of samples.
N < RL	Number of samples less than the Division analytical reporting level (RL).
Ref	Water quality reference (standard or action level); see NC Administrative Code 15A NCAC 2B .0200.
N > Ref	Number of samples greater than (or less than) the reference.
% > Ref	Proportion (%) of samples greater than the reference.
Min	Minimum.
Max	Maximum.
N/A	Not applicable because all samples were less than the reporting level.

Units of Measurement

As noted. Conductivity = µmhos/cm; bacteria = no. colonies/100 ml; chlorophyll *a* = µg/l; metals = µg/l; all others = mg/l.

Table 9. Summary of water quality parameters collected from the New River at Jacksonville (Station P1200000; Class SB NSW HQW; Subbasin 02) during the period 09/01/1994 to 8/31/1999.

								Percentiles				
Parameter	**N**	**N < RL**	**Ref.**	**N > Ref.**	**% > Ref.**	**Min.**	**Max.**	**10**	**25**	**50**	**75**	**90**
Field												
Temperature (^{o}C)	67	.	.	.	.	4	32	9	13	21	26	29
Conductivity	67	.	.	.	.	45	25580	184	397	3030	9490	17127
Dissolved Oxygen	66	.	5	14	21.2	0.0	14.3	2.9	5.4	7.6	10.2	12.6
pH (s.u.)	64	.	6.8; 8.5	15	23.4	6.0	9.0	6.6	7.0	7.3	7.9	8.3
Other												
Total Residue	0	0	.	.	.	.	.	.	.	.	.	.
Total Sus. Solids	41	1	.	.	.	1	18	2	4	6	9	14
Hardness	56	0	.	.	.	36	7100	67	105	600	2100	2900
Chloride	54	0	.	.	.	12	12000	49	180	1200	4300	7230
Turbidity (NTU)	56	0	25	0	.	1.9	22.0	2.8	3.8	4.9	6.8	11.0
Bacteria												
Total coliform	1	0	.	.	.	5100	5100	.	.	5100	.	.
Fecal coliform	66	9	200	16	24.2	9	4900	10	18	45	180	420
Nutrients												
NH_3 as N	66	12	.	.	.	0.01	0.34	0.01	0.02	0.06	0.10	0.15
TKN as N	66	0	.	.	.	0.3	1.3	0.4	0.4	0.6	0.7	0.9
NO_2+NO_3 as N	66	23	.	.	.	0.01	1.20	0.01	0.01	0.16	0.59	0.86
Total Phosphorus	66	0	.	.	.	0.06	0.64	0.08	0.11	0.14	0.18	0.22
Algal biomass												
Chl *a*	61	6	40	10	16	1.0	180	1.0	3.0	10	27	65
Metals (total)												
Arsenic	56	55	50	0	.	10	50	10	10	10	10	10
Cadmium	56	56	5	0	.	2	10	2	2	2	2	2
Chromium	56	56	20	0	.	25	125	25	25	25	25	25
Copper	56	33	3	16	28.6	2	55	2.0	2.0	2.0	4.0	8.0
Iron	56	0	.	.	.	88	1100	131	235	480	675	824
Lead	56	56	25	0	.	10	50	10	10	10	10	10
Manganese	0	0	.	.	.	.	.	.	.	.	.	.
Nickel	56	56	8.3	0	.	10	50	10	10	10	10	10
Aluminum	56	1	.	.	.	50	1600	98	145	245	390	621
Mercury	56	56	0.025	N/A	.	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Abbreviations:

N	Total number of samples.
N < RL	Number of samples less than the Division analytical reporting level (RL).
Ref	Water quality reference (standard or action level); see NC Administrative Code 15A NCAC 2B .0200.
N > Ref	Number of samples greater than (or less than) the reference.
% > Ref	Proportion (%) of samples greater than the reference.
Min	Minimum.
Max	Maximum.
N/A	Not applicable because all samples were less than the reporting level.

Units of Measurement

As noted. Conductivity = µmhos/cm; bacteria = no. colonies/100 ml; chlorophyll *a* = µg/l; metals = µg/l; all others = mg/l.

Table 10. Summary of water quality parameters collected from Little Northeast Creek (Station P3100000; Class C NSW; Subbasin 02) during the period 09/01/1994 to 08/31/1999.

Parameter	N	N < RL	Ref.	N > Ref.	% > Ref.	Min.	Max.	Percentiles 10	25	50	75	90
Field												
Temperature (^oC)	57	.	.	.	.	4	27	7	11	17	22	26
Conductivity	57	.	.	.	.	90	16642	131	153	232	553	1934
Dissolved Oxygen	56	.	5	20	35.7	0.2	11.6	2.3	4.2	6.4	8.6	10.1
pH (s.u.)	57	.	< 6;> 9	0	.	6.0	7.6	6.6	6.9	7.1	7.2	7.4
Other												
Total Residue	0	0	.	.	.	.	.	.	.	.	.	.
Total Sus. Solids	45	10	.	.	.	1	57	1	1	3	5	11
Hardness	58	0	100	.	.	30	2000	39	51	78	120	720
Chloride	1	0	.	.	.	1600	1600	.	.	1600	.	.
Turbidity (NTU)	58	0	50	0	.	1.3	13.0	2.8	3.7	4.4	6.6	9.3
Bacteria												
Total coliform	1	0	.	.	.	2200	2200	.	.	2200	.	.
Fecal coliform	60	1	200	24	40.0	10	3800	54	73	140	295	495
Nutrients												
NH_3 as N	61	9	.	.	.	0.01	0.26	0.01	0.02	0.04	0.10	0.13
TKN as N	61	0	.	.	.	0.1	1.1	0.2	0.2	0.3	0.4	0.6
NO_2+NO_3 as N	61	2	.	.	.	0.01	0.67	0.05	0.09	0.16	0.27	0.41
Total Phosphorus	61	0	.	.	.	0.02	0.40	0.03	0.05	0.08	0.13	0.19
Algal biomass												
Chl *a*	52	19	40	3	5.8	1.0	390	1.0	1.0	2.0	6.0	19
Metals (total)												
Arsenic	58	58	50	0	.	10	50	10	10	10	10	10
Cadmium	57	57	2	0	.	2	8	2	2	2	2	2
Chromium	57	57	50	0	.	25	125	25	25	25	25	25
Copper	57	33	7	8	14.0	2	14	2.0	2.0	2.0	4.0	8.8
Iron	57	0	1000	6	10.5	280	1300	362	480	670	785	1072
Lead	57	56	25	0	.	10	40	10	10	10	10	10
Manganese	1	0	.	.	.	22	22	.	.	22	.	.
Nickel	57	57	88	0	.	10	40	10	10	10	10	10
Aluminum	57	1	.	.	.	51	900	86	130	230	423	506
Mercury	58	58	0.012	N/A	.	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Abbreviations:

N	Total number of samples.
N < RL	Number of samples less than the Division analytical reporting level (RL).
Ref	Water quality reference (standard or action level); see NC Administrative Code 15A NCAC 2B .0200.
N > Ref	Number of samples greater than (or less than) the reference.
% > Ref	Proportion (%) of samples greater than the reference.
Min	Minimum.
Max	Maximum.
N/A	Not applicable because all samples were less than the reporting level.

Units of Measurement

As noted. Conductivity = µmhos/cm; bacteria = no. colonies/100 ml; chlorophyll *a* = µg/l; metals = µg/l; all others = mg/l.

Table 11. Summary of water quality parameters collected from Northeast Creek (Station P3700000; Class SC NSW HQW; Subbasin 02) during the period 09/01/1994 to 08/31/1999.

Parameter	N	N < RL	Ref.	N > Ref.	% > Ref.	Min.	Max.	Percentiles 10	25	50	75	90
Field												
Temperature (^{o}C)	65	.	.	.	.	5	32	9	14	21	26	30
Conductivity	65	.	.	.	.	5	29240	480	1943	10790	20904	24610
Dissolved Oxygen	65	.	5	14	21.5	0.8	15.9	3.9	5.8	7.9	9.6	11.2
pH (s.u.)	64	.	6.8; 8.5	15	23.4	6.3	8.5	6.5	6.9	7.3	7.6	8.0
Other												
Total Residue	0	0	.	.	.	.	.	.	.	.	.	.
Total Sus. Solids	39	0	.	.	.	1	48	3	5	10	13	23
Hardness	61	0	.	.	.	32	7400	100	380	1600	2700	3860
Chloride	57	0	.	.	.	22	17000	218	1400	4300	7125	10760
Turbidity (NTU)	60	0	25	0	.	2.5	23.0	3.0	4.0	5.0	7.0	9.1
Bacteria												
Total coliform	0	0	.	.		.	.	.	.	.	.	.
Fecal coliform	65	9	200	13	20.0	9	4700	10	19	64	146	300
Nutrients												
NH_3 as N	61	14	.	.	.	0.01	0.22	0.01	0.01	0.04	0.09	0.15
TKN as N	61	0	.	.	.	0.2	1.1	0.4	0.4	0.6	0.7	0.8
NO_2+NO_3 as N	61	25	.	.	.	0.01	0.35	0.01	0.01	0.03	0.10	0.20
Total Phosphorus	61	0	.	.	.	0.04	0.31	0.06	0.08	0.10	0.13	0.18
Algal biomass												
Chl *a*	54	2	40	10	18.5	1.0	270	5.0	8	15	26	77
Metals (total)												
Arsenic	60	59	50	0	.	10	50	10	10	10	10	12
Cadmium	60	59	5	0	.	2	10	2	2	2	2	2
Chromium	60	60	20	0	.	25	100	25	25	25	25	25
Copper	60	36	3	12	20.0	2	20	2.0	2.0	2.0	3.0	5.5
Iron	60	0	.		.	84	1100	115	170	300	485	730
Lead	60	60	25	0	.	10	50	10	10	10	10	40
Manganese	0	0	.	.	.	.	.	.	.	.	.	.
Nickel	60	60	8.3	0	.	10	50	10	10	10	10	10
Aluminum	59	0	.	.	.	50	2000	144	223	360	710	838
Mercury	60	60	0.025	N/A	.	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Abbreviations:

N	Total number of samples.
N < RL	Number of samples less than the Division analytical reporting level (RL).
Ref	Water quality reference (standard or action level); see NC Administrative Code 15A NCAC 2B .0200.
N > Ref	Number of samples greater than (or less than) the reference.
% > Ref	Proportion (%) of samples greater than the reference.
Min	Minimum.
Max	Maximum.
N/A	Not applicable because all samples were less than the reporting level.

Units of Measurement

As noted. Conductivity = µmhos/cm; bacteria = no. colonies/100 ml; chlorophyll *a* = µg/l; metals = µg/l; all others = mg/l.

Table 12. Summary of water quality parameters collected from Wallace Creek at Camp Lejeune (Station P4400000; Class SB NSW; Subbasin 02) during the period 09/01/1994 to 08/31/1999.

Parameter	N	N < RL	Ref.	N > Ref.	% > Ref.	Min.	Max.	Percentiles 10	25	50	75	90
Field												
Temperature (^{o}C)	61	.	.	.	.	7	32	9	13	21	27	29
Conductivity	61	.	.	.	.	324	31830	2820	8540	19100	23475	28664
Dissolved Oxygen	61	.	5	5	8.2	2.1	12.8	5.1	6.9	8.5	9.6	11.1
pH (s.u.)	61	.	6.8; 8.5	5	8.2	6.4	8.1	7.0	7.2	7.6	7.8	7.9
Other												
Total Residue	0	0	.	.	.	.	.	.	.	.	.	.
Total Sus. Solids	41	0	.	.	.	2	71	3	6	8	14	19
Hardness	58	0	.	.	.	63	9100	775	1800	2650	3800	4140
Chloride	56	0	.	.	.	80	21000	2000	3550	6700	9850	13800
Turbidity (NTU)	57	0	25	0	.	1.2	12.0	2.1	2.5	3.0	3.9	4.7
Bacteria												
Total coliform	0	0	.	.		.	.	.	.	.	.	.
Fecal coliform	59	27	200	7	11.9	9	3800	10	10	10	54	246
Nutrients												
NH_3 as N	59	14	.	.	.	0.01	0.16	0.01	0.01	0.02	0.06	0.10
TKN as N	59	0	.	.	.	0.2	0.9	0.3	0.4	0.5	0.6	0.7
NO_2+NO_3 as N	59	46	.	.	.	0.01	0.13	0.01	0.01	0.01	0.01	0.03
Total Phosphorus	59	0	.	.	.	0.01	0.11	0.03	0.04	0.05	0.07	0.08
Algal biomass												
Chl *a*	55	0	40	7	12.7	2.0	150	4.6	6.0	10	25	47
Metals (total)												
Arsenic	58	58	50	0	.	10	50	10	10	10	10	10
Cadmium	58	58	5	0	.	2	10	2	2	2	2	8
Chromium	58	58	20	0	.	25	100	25	25	25	25	25
Copper	58	37	3	15	25.9	2	35	2.0	2.0	2.0	3.6	8.8
Iron	58	3	.	.	.	62	690	77	100	140	200	290
Lead	58	57	25	0	.	10	50	10	10	10	10	47
Manganese	0	0	.	.	.	.	.	.	.	.	.	.
Nickel	58	57	8.3	1	1.7	10	50	10	10	10	10	40
Aluminum	58	2	.	.	.	50	690	97	130	200	310	479
Mercury	58	58	0.025	N/A	.	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Abbreviations:

N	Total number of samples.
N < RL	Number of samples less than the Division analytical reporting level (RL).
Ref	Water quality reference (standard or action level); see NC Administrative Code 15A NCAC 2B .0200.
N > Ref	Number of samples greater than (or less than) the reference.
% > Ref	Proportion (%) of samples greater than the reference.
Min	Minimum.
Max	Maximum.
N/A	Not applicable because all samples were less than the reporting level.

Units of Measurement

As noted. Conductivity = µmhos/cm; bacteria = no. colonies/100 ml; chlorophyll *a* = µg/l; metals = µg/l; all others = mg/l.

Table 13. Summary of water quality parameters collected from the New River near Sneads Ferry (Station P4750000; Class SA) during the period 09/01/1994 to 08/31/1999.

Parameter	N	N < RL	Ref.	N > Ref.	% > Ref.	Min.	Max.	Percentiles 10	25	50	75	90
Field												
Temperature (^{o}C)	58	.	.	.	.	6	31	9	13	19	26	28
Conductivity	58	.	.	.	.	7050	45700	22390	30300	37396	41000	42596
Dissolved Oxygen	57	.	5	0	.	5.1	11.9	6.1	6.5	7.8	9.9	11.0
pH (s.u.)	58	.	6.8; 8.5	0	.	7.1	8.2	7.4	7.6	7.8	8.0	8.1
Other												
Total Residue	0	0	.	.	.	.	.	.	.	.	.	.
Total Sus. Solids	36	0	.	.	.	2	65	5	11	19	27	38
Hardness	56	0	.	.	.	780	10000	3110	3950	4800	5450	6580
Chloride	54	0	.	.	.	1000	32000	6990	9400	14000	17000	28100
Turbidity (NTU)	55	0	25	0	.	1.3	14.0	1.8	2.6	3.8	6.0	7.9
Bacteria												
Total coliform	0	0	.	.	.	.	.	.	.	.	.	.
Fecal coliform	56	50	14	3	5.4	5	82	10	10	10	10	10
Nutrients												
NH_3 as N	56	10	.	.	.	0.01	0.47	0.01	0.01	0.03	0.10	0.15
TKN as N	56	0	.	.	.	0.2	0.9	0.2	0.3	0.5	0.6	0.7
NO_2+NO_3 as N	56	46	.	.	.	0.01	0.05	0.01	0.01	0.01	0.01	0.02
Total Phosphorus	56	0	.	.	.	0.01	0.11	0.02	0.03	0.04	0.05	0.06
Algal biomass												
Chl *a*	54	3	40	1	1.9	1.0	41	1.5	3.0	4.0	8.0	12
Metals (total)												
Arsenic	55	55	50	0	.	10	50	10	10	10	10	40
Cadmium	56	56	5	0	.	2	10	2	2	2	8	10
Chromium	56	56	20	0	.	25	100	25	25	25	25	25
Copper	56	40	3	3	5.4	2	15	2.0	2.0	2.0	2.7	4.4
Iron	56	3	.	.	.	50	1200	80	110	190	285	447
Lead	56	53	25	0	.	10	50	10	10	10	40	50
Manganese	0	0	.	.	.	.	.	.	.	.	.	.
Nickel	56	54	8.3	2	3.6	10	50	10	10	10	10	40
Aluminum	56	1	.	.	.	100	1900	162	190	335	530	713
Mercury	56	56	0.025	N/A	.	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Abbreviations:

N	Total number of samples.
N < RL	Number of samples less than the Division analytical reporting level (RL).
Ref	Water quality reference (standard or action level); see NC Administrative Code 15A NCAC 2B .0200.
N > Ref	Number of samples greater than (or less than) the reference.
% > Ref	Proportion (%) of samples greater than the reference.
Min	Minimum.
Max	Maximum.
N/A	Not applicable because all samples were less than the reporting level.

Units of Measurement

As noted. Conductivity = µmhos/cm; bacteria = no. colonies/100 ml; chlorophyll *a* = µg/l; metals = µg/l; all others = mg/l.

Table 14. Summary of water quality parameters collected from the White Oak River near Stella (Station P6400000; Class SA) during the period 09/01/1994 to 08/31/1999.

Parameter	N	N < RL	Ref.	N > Ref.	% > Ref.	Min.	Max.	Percentiles 10	25	50	75	90
Field												
Temperature (^{o}C)	60	.	.	.	.	7	32	9	12	18	26	29
Conductivity	60	.	.	.	.	24.5	39254	217	538	5825	18920	25251
Dissolved Oxygen	59	.	5	7	11.9	0.0	11.2	4.5	5.8	7.1	8.5	9.1
pH (s.u.)	60	.	6.8; 8.5	16	26.7	6.2	7.6	6.6	6.8	7.0	7.1	7.4
Other												
Total Residue	0	0	.	.	.	.	.	.	.	.	.	.
Total Sus. Solids	39	1	.	.	.	1	29	3	5	8	12	21
Hardness	59	0	.	.	.	31	10000	60	125	1100	2875	3760
Chloride	59	1	.	.	.	1	21000	35	102	1800	6475	11200
Turbidity (NTU)	59	0	25	1	1.7	1.4	50.0	2.0	2.8	3.6	4.4	7.4
Bacteria												
Total coliform	0	0	.	.	.	.	.	.	.	.	.	.
Fecal coliform	59	7	14	50	84.7	9	260	10	20	45	91	146
Nutrients												
NH_3 as N	61	17	.	.	.	0.01	0.27	0.01	0.01	0.02	0.07	0.08
TKN as N	61	0	.	.	.	0.2	0.9	0.3	0.3	0.4	0.6	0.7
NO_2+NO_3 as N	61	17	.	.	.	0.01	0.19	0.01	0.01	0.03	0.07	0.11
Total Phosphorus	61	0	.	.	.	0.03	0.34	0.05	0.06	0.07	0.09	0.11
Metals (total)												
Arsenic	59	59	50	0	.	10	50	10	10	10	10	28
Cadmium	59	58	5	1	1.7	2	14	2	2	2	2	8
Chromium	59	59	20	1	1.7	25	100	25	25	25	25	25
Copper	59	38	3	15	25.4	2	25	2.0	2.0	2.0	3.1	11.6
Iron	59	1	.	.	.	130	1200	190	253	370	585	786
Lead	59	59	25	0	.	10	50	10	10	10	10	40
Manganese	1	0	.	.	.	12	12	.	.	12	.	.
Nickel	59	59	8.3	0	.	10	40	10	10	10	10	10
Aluminum	59	0	.	.	.	140	1300	220	275	410	553	756
Mercury	59	59	0.025	N/A	.	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Abbreviations:

N	Total number of samples.
N < RL	Number of samples less than the Division analytical reporting level (RL).
Ref	Water quality reference (standard or action level); see NC Administrative Code 15A NCAC 2B .0200.
N > Ref	Number of samples greater than (or less than) the reference.
% > Ref	Proportion (%) of samples greater than the reference.
Min	Minimum.
Max	Maximum.
N/A	Not applicable because all samples were less than the reporting level.

Units of Measurement

As noted. Conductivity = µmhos/cm; bacteria = no. colonies/100 ml; metals = µg/l; all others = mg/l.

Table 15. Summary of water quality parameters collected from the White Oak River at Swansboro (Station P6850000; Class SA) during the period 09/01/1994 to 08/31/1999.

Parameter	N	N < RL	Ref.	N > Ref.	% > Ref.	Min.	Max.	Percentiles 10	25	50	75	90
Field												
Temperature (^{o}C)	58	.	.	.	.	7	30	9	13	18	26	28
Conductivity	59	.	.	.	.	12940	55010	31360	38475	44300	48327	51050
Dissolved Oxygen	58	.	5	0	.	5.2	10.8	5.8	6.5	7.7	8.9	10.0
pH (s.u.)	59	.	6.8; 8.5	0	.	7.2	8.2	7.4	7.5	7.7	7.9	8.0
Other												
Total Residue	0	0	.	.	.	.	.	.	.	.	.	.
Total Sus. Solids	38	0	.	.	.	1	120	5	11	16	34	44
Hardness	56	0	.	.	.	110	15000	3820	5550	6200	6800	7570
Chloride	58	0	.	.	.	82	39000	9370	14000	18000	20000	35000
Turbidity (NTU)	58	2	25	0	.	1.0	13.0	1.4	2.2	3.2	4.1	5.2
Bacteria												
Total coliform	0	0	.	.	.	.	.	.	.	.	.	.
Fecal coliform	57	41	14	9	15.8	9	27	10	10	10	10	18
Nutrients												
NH_3 as N	59	18	.	.	.	0.01	0.45	0.01	0.01	0.03	0.09	0.17
TKN as N	59	0	.	.	.	0.1	0.9	0.2	0.3	0.4	0.6	0.7
NO_2+NO_3 as N	59	40	.	.	.	0.01	0.05	0.01	0.01	0.01	0.01	0.03
Total Phosphorus	59	2	.	.	.	0.01	0.27	0.01	0.02	0.03	0.04	0.06
Metals (total)												
Arsenic	58	56	50	0	.	10	50	10	10	10	10	47
Cadmium	58	56	5	2	3.4	2	12	2	2	2	8	10
Chromium	58	58	20	0	.	25	125	25	25	25	25	25
Copper	58	36	3	11	19.0	2	15	2.0	2.0	2.0	3.0	6.2
Iron	58	3	.	.	.	59	860	88	150	195	240	307
Lead	58	56	25	1	1.7	10	68	10	10	10	40	50
Manganese	1	1	.	.	.	10	10	.	.	10	.	.
Nickel	58	57	8.3	1	1.7	10	50	10	10	10	10	40
Aluminum	58	0	.	.	.	93	960	120	190	290	390	513
Mercury	58	58	0.025	N/A	.	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Abbreviations:

N	Total number of samples.
N < RL	Number of samples less than the Division analytical reporting level (RL).
Ref	Water quality reference (standard or action level); see NC Administrative Code 15A NCAC 2B .0200.
N > Ref	Number of samples greater than (or less than) the reference.
% > Ref	Proportion (%) of samples greater than the reference.
Min	Minimum.
Max	Maximum.
N/A	Not applicable because all samples were less than the reporting level.

Units of Measurement

As noted. Conductivity = µmhos/cm; bacteria = no. colonies/100 ml; metals = µg/l; all others = mg/l.

Table 16. Summary of water quality parameters collected from the Newport River at Newport (Station P7300000; Class C) during the period 09/01/1994 to 08/31/1999.

Parameter	N	N < RL	Ref.	N > Ref.	% > Ref.	Min.	Max.	Percentiles 10	25	50	75	90
Field												
Temperature (^{o}C)	56	.	.	.	.	5	31	7	11	17	24	26
Conductivity	56	.	.	.	.	86	5250	124	155	210	358	894
Dissolved Oxygen	56	.	5	22	39.3	1.6	9.7	3.4	4.3	5.6	7.5	9.0
pH (s.u.)	56	.	< 6; > 9	5	8.9	5.3	7.6	6.0	6.5	6.7	6.9	7.2
Other												
Total Residue	0	0	.	.	.	.	.	.	.	.	.	.
Total Sus. Solids	38	2	.	.	.	1	35	2	4	9	15	29
Hardness	57	0	.	.	.	18	4200	31	46	66	95	194
Chloride	54	0	230	.	.	15	12000	19	27	37	58	232
Turbidity (NTU)	57	0	50	5	8.8	1.7	24.0	2.7	4.0	6.3	9.9	14.8
Bacteria												
Total coliform	0	0	.	.		.	.	.	.	.	.	.
Fecal coliform	57	0	200	18	31.6	18	1500	51	110	160	238	420
Nutrients												
NH_3 as N	58	13	.	.	.	0.01	0.16	0.01	0.01	0.05	0.08	0.13
TKN as N	58	0	.	.	.	0.3	0.9	0.3	0.4	0.5	0.5	0.7
NO_2+NO_3 as N	58	1	.	.	.	0.01	0.98	0.05	0.09	0.16	0.29	0.50
Total Phosphorus	58	1	.	.	.	0.01	0.18	0.02	0.04	0.06	0.09	0.13
Metals (total)												
Arsenic	57	57	50	0	.	10	50	10	10	10	10	10
Cadmium	57	57	2	0	.	2	2	2	2	2	2	2
Chromium	57	57	50	0	.	25	25	25	25	25	25	25
Copper	57	31	7	6	10.5	2	30	2.0	2.0	2.0	4.0	7.8
Iron	57	0	1000	22	38.6	170	2200	492	668	940	1300	1680
Lead	57	57	25	0	.	10	40	10	10	10	10	10
Manganese	1	0	.	.	.	12	12	.	.	12	.	.
Nickel	57	57	88	0	.	10	10	10	10	10	10	10
Aluminum	57	0	.	.	.	200	1600	494	630	790	973	1100
Mercury	57	57	0.012	N/A	.	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Abbreviations:

N	Total number of samples.
N < RL	Number of samples less than the Division analytical reporting level (RL).
Ref	Water quality reference (standard or action level); see NC Administrative Code 15A NCAC 2B .0200.
N > Ref	Number of samples greater than (or less than) the reference.
% > Ref	Proportion (%) of samples greater than the reference.
Min	Minimum.
Max	Maximum.
N/A	Not applicable because all samples were less than the reporting level.

Units of Measurement

As noted. Conductivity = µmhos/cm; bacteria = no. colonies/100 ml; metals = µg/l; all others = mg/l.

Table 17. Summary of water quality parameters collected from the Newport River at Channel Marker G '1' near Morehead City (Station P8700000; Class SA) during the period 09/01/1994 to 08/31/1999.

Parameter	N	N < RL	Ref.	N > Ref.	% > Ref.	Min.	Max.	Percentiles 10	25	50	75	90
Field												
Temperature (^{o}C)	51	.	.	.	.	9	29	10	13	18	24	28
Conductivity	51	.	.	.	.	31	54370	29725	37175	43600	47355	50275
Dissolved Oxygen	50	.	5	1	2.0	0.9	11.1	6.0	6.5	7.7	8.8	10.2
pH (s.u.)	52	.	6.8; 8.5	0	.	6.9	8.3	7.6	7.6	7.7	7.9	8.1
Other												
Total Residue	0	0	.	.	.	.	.	.	.	.	.	.
Total Sus. Solids	31	0	.	.	.	4	96	8	14	22	33	43
Hardness	48	0	.	.	.	2900	14000	3960	5400	6000	6450	7140
Chloride	49	0	.	.	.	5800	38000	11400	15000	18000	24000	35000
Turbidity (NTU)	50	0	25	0	.	1.2	15.0	1.7	2.9	3.8	5.4	7.8
Bacteria												
Total coliform	0	0	.	.	.	.	.	.	.	.	.	.
Fecal coliform	49	44	14	1	2.0	1	20	10	10	10	10	10
Nutrients												
NH_3 as N	49	16	.	.	.	0.01	0.30	0.01	0.01	0.02	0.04	0.16
TKN as N	49	0	.	.	.	0.1	0.7	0.3	0.3	0.3	0.4	0.6
NO_2+NO_3 as N	49	39	.	.	.	0.01	0.07	0.01	0.01	0.01	0.01	0.03
Total Phosphorus	49	4	.	.	.	0.01	0.09	0.01	0.02	0.03	0.04	0.06
Metals (total)												
Arsenic	49	49	50	0	.	10	50	10	10	10	10	40
Cadmium	49	49	5	0	.	2	10	2	2	8	8	10
Chromium	49	48	20	1	.	25	100	25	25	25	25	77
Copper	49	38	3	7	14.3	2	15	2.0	2.0	2.0	2.0	4.0
Iron	49	4	.	.	.	53	1000	87	140	200	288	396
Lead	49	48	25	0	.	10	50	10	10	40	50	50
Manganese	1	0	.	.	.	20	20	.	.	20	.	.
Nickel	49	49	8.3	0	.	10	50	10	10	10	10	40
Aluminum	49	2	.	.	.	50	1800	200	228	390	513	674
Mercury	49	49	0.025	N/A	.	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Abbreviations:

N	Total number of samples.
N < RL	Number of samples less than the Division analytical reporting level (RL).
Ref	Water quality reference (standard or action level); see NC Administrative Code 15A NCAC 2B .0200.
N > Ref	Number of samples greater than (or less than) the reference.
% > Ref	Proportion (%) of samples greater than the reference.
Min	Minimum.
Max	Maximum.
N/A	Not applicable because all samples were less than the reporting level.

Units of Measurement

As noted. Conductivity = µmhos/cm; bacteria = no. colonies/100 ml; metals = µg/l; all others = mg/l.

Table 18. Summary of water quality parameters collected from the Morehead City Harbor at Channel Marker G '15' (Station P8965500; Class SA) during the period 09/01/1994 to 08/31/1999.

Parameter	N	N < RL	Ref.	N > Ref.	% > Ref.	Min.	Max.	Percentiles 10	25	50	75	90
Field												
Temperature (^{o}C)	52	.	.	.	.	8	28	10	13	18	24	28
Conductivity	52	.	.	.	.	49	512000	41780	47195	48725	50650	52230
Dissolved Oxygen	51	.	5	0	.	5.9	11.0	6.1	6.6	7.6	8.7	9.6
pH (s.u.)	51	.	6.8; 8.5	0	.	7.1	8.2	7.6	7.7	7.8	8.0	8.1
Other												
Total Residue	0	0	.	.	.	.	.	.	.	.	.	.
Total Sus. Solids	30	0	.	.	.	5	150	10	16	24	35	55
Hardness	48	0	.	.	.	700	12000	5030	6000	6600	7200	7940
Chloride	50	0	.	.	.	8400	43000	15500	17000	19000	31000	37500
Turbidity (NTU)	50	0	25	0	.	1.1	8.0	1.3	1.8	2.5	3.4	4.9
Bacteria												
Total coliform	0	0	.	.	.	.	.	.	.	.	.	.
Fecal coliform	49	46	14	1	2.0	1	60	10	10	10	10	10
Nutrients												
NH_3 as N	50	16	.	.	.	0.01	0.32	0.01	0.01	0.03	0.06	0.18
TKN as N	50	0	.	.	.	0.1	1.0	0.2	0.3	0.3	0.4	0.5
NO_2+NO_3 as N	50	41	.	.	.	0.01	0.04	0.01	0.01	0.01	0.01	0.01
Total Phosphorus	50	11	.	.	.	0.01	0.15	0.01	0.01	0.02	0.03	0.04
Metals (total)												
Arsenic	49	49	50	0	.	10	50	10	10	10	10	40
Cadmium	49	49	5	0	.	2	10	2	2	8	10	10
Chromium	49	48	20	1	2.0	25	100	25	25	25	25	100
Copper	49	38	3	8	16.3	2	35	2.0	2.0	2.0	2.1	4.7
Iron	49	6	.	.	.	50	610	62	87	150	220	318
Lead	49	49	25	.	.	10	50	10	10	40	40	50
Manganese	1	0	.	.	.	11	11	.	.	11	.	.
Nickel	49	48	8.3	1	2.0	10	65	10	10	10	18	46
Aluminum	49	2	.	.	.	50	900	120	148	250	395	618
Mercury	49	49	0.025	N/A	.	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Abbreviations:

N	Total number of samples.
N < RL	Number of samples less than the Division analytical reporting level (RL).
Ref	Water quality reference (standard or action level); see NC Administrative Code 15A NCAC 2B .0200.
N > Ref	Number of samples greater than (or less than) the reference.
% > Ref	Proportion (%) of samples greater than the reference.
Min	Minimum.
Max	Maximum.
N/A	Not applicable because all samples were less than the reporting level.

Units of Measurement

As noted. Conductivity = µmhos/cm; bacteria = no. colonies/100 ml; metals = µg/l; all others = mg/l.

Table 19. Summary of water quality parameters collected from the North River (P8975000; Class SA) during the period 09/01/1994 to 08/31/1999.

Parameter	N	N < RL	Ref.	N > Ref.	% > Ref.	Min.	Max.	Percentiles 10	25	50	75	90
Field												
Temperature (^{o}C)	55	.	.	.	.	4	32	8	11	19	27	30
Conductivity	55	.	.	.	.	14350	50000	24800	30553	39800	44013	46200
Dissolved Oxygen	53	.	5	0	.	5.0	11.7	6.4	7.1	8.1	9.9	10.9
pH (s.u.)	54	.	6.8; 8.5	0	.	6.9	8.1	7.4	7.5	7.7	7.8	7.9
Other												
Total Residue	0	0	.	.	.	.	.	.	.	.	.	.
Total Sus. Solids	35	0	.	.	.	1	300	2	13	26	50	80
Hardness	55	0	.	.	.	30	16000	3400	4000	5500	6200	7300
Chloride	54	0	.	.	.	26	38000	8670	11000	15000	27000	32000
Turbidity (NTU)	55	0	25	5	9.1	1.0	100.0	2.2	4.5	10.0	15.0	24.0
Bacteria												
Total coliform	0	0	.	.	.	.	.	.	.	.	.	.
Fecal coliform	53	39	14	11	20.8	9	330	10	10	10	10	27
Nutrients												
NH_3 as N	56	16	.	.	.	0.01	0.29	0.01	0.01	0.03	0.08	0.20
TKN as N	56	0	.	.	.	0.1	2.8	0.3	0.4	0.4	0.6	0.7
NO_2+NO_3 as N	56	34	.	.	.	0.01	0.23	0.01	0.01	0.01	0.02	0.06
Total Phosphorus	55	3	.	.	.	0.01	0.25	0.01	0.02	0.05	0.07	0.12
Metals (total)												
Arsenic	55	55	50	0	.	10	50	10	10	10	10	40
Cadmium	55	55	5	0	.	2	10	2	2	2	9.5	10
Chromium	55	55	20	0	.	25	100	25	25	25	25	25
Copper	55	37	3	11	20.0	2	20	2.0	2.0	2.0	3.0	6.0
Iron	55	1	.	.	.	50	6400	140	270	750	1150	2200
Lead	55	55	25	0	.	10	50	10	10	10	50	50
Manganese	2	1	.	.	.	10	30	.	10	20	30	.
Nickel	55	55	8.3	0	.	10	50	10	10	10	10	50
Aluminum	55	1	.	.	.	50	9200	320	473	960	1900	2900
Mercury	55	55	0.025	N/A	.	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Abbreviations:

N	Total number of samples.
N < RL	Number of samples less than the Division analytical reporting level (RL).
Ref	Water quality reference (standard or action level); see NC Administrative Code 15A NCAC 2B .0200.
N > Ref	Number of samples greater than (or less than) the reference.
% > Ref	Proportion (%) of samples greater than the reference.
Min	Minimum.
Max	Maximum.
N/A	Not applicable because all samples were less than the reporting level.

Units of Measurement

As noted. Conductivity = µmhos/cm; bacteria = no. colonies/100 ml; metals = µg/l; all others = mg/l.

Table 20. Summary of water quality parameters collected from Ward Creek near Otway (Station P8976000; Class SA) during the period 09/01/1994 to 08/31/1999.

Parameter	N	N < RL	Ref.	N > Ref.	% > Ref.	Min.	Max.	Percentiles 10	25	50	75	90
Field												
Temperature (^{o}C)	58	.	.	.	.	6	34	8	12	19	27	30
Conductivity	58	.	.	.	.	2379	50200	20750	30800	39932	44000	47801
Dissolved Oxygen	57	.	5	0	.	5.0	12.6	6.4	7.0	8.0	9.8	10.9
pH (s.u.)	58	.	6.8; 8.5	1	1.7	6.7	8.1	7.3	7.5	7.6	7.8	8.0
Other												
Total Residue	0	0	.	.	.	.	.	.	.	.	.	.
Total Sus. Solids	38	0	.	.	.	1	200	5	14	28	41	58
Hardness	57	0	.	.	.	32	14000	2840	4075	5200	6100	7400
Chloride	57	0	.	.	.	1200	38000	7200	11750	15000	19750	31000
Turbidity (NTU)	56	1	25	.	.	1.0	65.0	1.7	4.1	9.6	13.0	20.0
Bacteria												
Total coliform	0	0	.	.		.	.	.	.	.	.	.
Fecal coliform	57	33	14	18	31.6	9	600	10	10	10	22	86
Nutrients												
NH_3 as N	59	15	.	.	.	0.01	0.40	0.01	0.01	0.02	0.08	0.18
TKN as N	59	0	.	.	.	0.2	4.2	0.2	0.3	0.5	0.6	0.8
NO_2+NO_3 as N	59	38	.	.	.	0.01	0.38	0.01	0.01	0.01	0.02	0.07
Total Phosphorus	59	0	.	.	.	0.01	0.43	0.02	0.03	0.05	0.08	0.12
Metals (total)												
Arsenic	57	57	50	0	.	10	50	10	10	10	10	34
Cadmium	57	57	5	0	.	2	10	2	2	2	8	10
Chromium	57	56	20	1	1.8	25	125	25	25	25	25	25
Copper	57	35	3	11	19.3	2	17	2.0	2.0	2.0	3.0	4.9
Iron	57	1	.	.	.	50	3800	92	260	490	1025	1680
Lead	57	56	25	0	.	10	50	10	10	10	40	50
Manganese	2	1	.	.	.	10	26	.	10	18	26	.
Nickel	57	57	8.3	0	.	10	50	10	10	10	10	40
Aluminum	57	0	.	.	.	70	4800	164	365	750	1675	2620
Mercury	57	57	0.025	N/A	.	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Abbreviations:

N	Total number of samples.
N < RL	Number of samples less than the Division analytical reporting level (RL).
Ref	Water quality reference (standard or action level); see NC Administrative Code 15A NCAC 2B .0200.
N > Ref	Number of samples greater than (or less than) the reference.
% > Ref	Proportion (%) of samples greater than the reference.
Min	Minimum.
Max	Maximum.
N/A	Not applicable because all samples were less than the reporting level.

Units of Measurement

As noted. Conductivity = µmhos/cm; bacteria = no. colonies/100 ml; metals = µg/l; all others = mg/l.

Table 21. Summary of water quality parameters collected from Broad Creek near Masontown (Station P8978000; Class SA ORW) during the period 09/01/1994 to 08/31/1999.

Parameter	N	N < RL	Ref.	N > Ref.	% > Ref.	Min.	Max.	Percentiles 10	25	50	75	90
Field												
Temperature (^{o}C)	56	.	.	.	.	5	33	10	14	19	28	30
Conductivity	56	.	.	.	.	309	49360	1038	9054	22762	33173	37770
Dissolved Oxygen	55	.	5	7	12.7	0.1	11.6	4.4	5.7	7.4	9.1	10.3
pH (s.u.)	55	.	6.8; 8.5	11	20.0	5.8	8.0	6.5	7.0	7.3	7.6	7.8
Other												
Total Residue	0	0	.	.	.	.	.	.	.	.	.	.
Total Sus. Solids	38	0	.	.	.	2	280	4	8	15	27	44
Hardness	57	0	.	.	.	65	19000	196	1500	3200	4925	5680
Chloride	56	0	.	.	.	56	39000	245	3950	10500	15000	21000
Turbidity (NTU)	57	1	25	1	1.8	1.0	38.0	2.8	4.7	6.3	8.4	11.0
Bacteria												
Total coliform	0	0	.	.	.	.	.	.	.	.	.	.
Fecal coliform	56	7	200	0	.	10	2800	10	40	115	215	428
Nutrients												
NH_3 as N	58	11	.	.	.	0.01	0.70	0.01	0.02	0.07	0.12	0.18
TKN as N	58	0	.	.	.	0.2	1.5	0.3	0.4	0.6	0.7	0.9
NO_2+NO_3 as N	58	18	.	.	.	0.01	1.70	0.01	0.01	0.04	0.37	1.34
Total Phosphorus	58	0	.	.	.	0.02	1.30	0.03	0.05	0.09	0.23	0.36
Metals (total)												
Arsenic	57	56	50	0	.	10	50	10	10	10	10	34
Cadmium	57	57	5	0	.	2	10	2	2	2	8	10
Chromium	57	57	20	0	.	25	125	25	25	25	25	25
Copper	57	37	3	10	17.5	2	14	2.0	2.0	2.0	3.0	6.8
Iron	57	1	.	.	.	50	1100	132	260	340	460	556
Lead	57	56	25	0	.	10	50	10	10	10	10	50
Manganese	1	0	.	.	.	22	22	.	.	22	.	.
Nickel	57	55	8.3	2	3.5	10	50	10	10	10	10	35
Aluminum	57	0	.	.	.	68	2500	202	490	690	963	1180
Mercury	57	57	0.025	N/A	.	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Abbreviations:

N	Total number of samples.
N < RL	Number of samples less than the Division analytical reporting level (RL).
Ref	Water quality reference (standard or action level); see NC Administrative Code 15A NCAC 2B .0200.
N > Ref	Number of samples greater than (or less than) the reference.
% > Ref	Proportion (%) of samples greater than the reference.
Min	Minimum.
Max	Maximum.
N/A	Not applicable because all samples were less than the reporting level.

Units of Measurement

As noted. Conductivity = µmhos/cm; bacteria = no. colonies/100 ml; metals = µg/l; all others = mg/l.

Table 22. Summary of water quality parameters collected from the North River near Beaufort (Station P8990000; Class SA) during the period 09/01/1994 to 08/31/1999.

Parameter	N	N < RL	Ref.	N > Ref.	% > Ref.	Min.	Max.	Percentiles 10	25	50	75	90
Field												
Temperature (^{o}C)	54	.	.	.	.	6	29	10	13	18	24	28
Conductivity	54	.	.	.	.	41	54630	37962	44000	47050	49703	51010
Dissolved Oxygen	53	.	5	0	.	5.5	11.0	6.2	6.6	7.8	8.7	9.9
pH (s.u.)	53	.	6.8; 8.5	1	1.9	6.9	9.7	7.6	7.7	7.8	7.9	8.1
Other												
Total Residue	0	0	.	.	.	.	.	.	.	.	.	.
Total Sus. Solids	33	0	.	.	.	7	160	8	12	20	33	53
Hardness	52	0	.	.	.	62	14000	4450	5550	6400	6950	7230
Chloride	53	0	.	.	.	6700	57000	14000	16750	18000	24500	36000
Turbidity (NTU)	53	1	25	0	.	1.0	13.0	1.2	2.0	3.0	4.3	5.7
Bacteria												
Total coliform	0	0	.	.	.	.	.	.	.	.	.	.
Fecal coliform	53	51	200	0	.	1	10	10	10	10	10	10
Nutrients												
NH_3 as N	54	21	.	.	.	0.01	0.29	0.01	0.01	0.02	0.06	0.17
TKN as N	54	0	.	.	.	0.2	0.6	0.2	0.2	0.4	0.4	0.5
NO_2+NO_3 as N	54	46	.	.	.	0.01	0.08	0.01	0.01	0.01	0.01	0.01
Total Phosphorus	54	6	.	.	.	0.01	0.08	0.01	0.01	0.02	0.03	0.04
Metals (total)												
Arsenic	53	53	50	0	.	10	50	10	10	10	10	40
Cadmium	53	53	5	0	.	2	10	2	2	8	10	10
Chromium	53	51	20	2	3.8	25	100	25	25	25	25	40
Copper	53	39	3	6	11.3	2	33	2.0	2.0	2.0	2.2	3.6
Iron	53	4	.	.	.	50	920	64	108	190	263	320
Lead	53	53	25	0	.	10	50	10	10	40	50	50
Manganese	1	1	.	.	.	10	10	.	.	10	.	.
Nickel	53	52	8.3	1	1.9	10	65	10	10	10	18	50
Aluminum	53	2	.	.	.	50	1900	120	180	360	493	648
Mercury	53	53	0.025	NA	.	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Abbreviations:

N	Total number of samples.
N < RL	Number of samples less than the Division analytical reporting level (RL).
Ref	Water quality reference (standard or action level); see NC Administrative Code 15A NCAC 2B .0200.
N > Ref	Number of samples greater than (or less than) the reference.
% > Ref	Proportion (%) of samples greater than the reference.
Min	Minimum.
Max	Maximum.
N/A	Not applicable because all samples were less than the reporting level.

Units of Measurement

As noted. Conductivity = µmhos/cm; bacteria = no. colonies/100 ml; metals = µg/l; all others = mg/l.

Table 23. Summary of water quality parameters collected from Bogue Sound near Salter Path (Station P9580000; Class SA ORW) during the period 09/01/1994 to 08/31/1999.

Parameter	N	N < RL	Ref.	N > Ref.	% > Ref.	Min.	Max.	Percentiles 10	25	50	75	90
Field												
Temperature (^{o}C)	49	.	.	.	.	7	31	10	13	19	25	29
Conductivity	49	.	.	.	.	41	52200	38280	42750	46732	49180	50820
Dissolved Oxygen	48	.	5	0	.	5.7	11.1	6.5	6.8	7.5	9.4	10.3
pH (s.u.)	47	.	6.8; 8.5	0	.	7.4	8.1	7.6	7.7	7.8	8.0	8.0
Other												
Total Residue	0	0	.	.	.	.	.	.	.	.	.	.
Total Sus. Solids	35	0	.	.	.	4	100	9	15	20	34	40
Hardness	48	0	.	.	.	3000	14000	4590	5650	6200	7050	7570
Chloride	52	0	.	.	.	54	39000	14700	17000	19000	25500	36000
Turbidity (NTU)	51	4	25	0	.	1.0	14.0	1.1	1.9	3.6	5.0	7.1
Bacteria												
Total coliform	0	0	.	.	.	.	.	.	.	.	.	.
Fecal coliform	52	48	200	0	.	1	10	10	10	10	10	10
Nutrients												
NH_3 as N	51	17	.	.	.	0.01	1.30	0.01	0.01	0.03	0.06	0.16
TKN as N	51	0	.	.	.	0.1	0.8	0.2	0.3	0.3	0.4	0.5
NO_2+NO_3 as N	51	44	.	.	.	0.01	0.03	0.01	0.01	0.01	0.01	0.01
Total Phosphorus	51	5	.	.	.	0.01	0.13	0.01	0.02	0.03	0.04	0.05
Metals (total)												
Arsenic	51	51	50	0	.	10	50	10	10	10	10	22
Cadmium	51	50	5	0	.	2	10	2	2	8	8	10
Chromium	51	51	20	0	.	25	125	25	25	25	25	25
Copper	51	32	3	10	19.6	2	22	2.0	2.0	2.0	3.0	7.2
Iron	51	4	.	.	.	50	1000	62	103	250	300	474
Lead	51	49	25	0	.	10	50	10	10	17	48	50
Manganese	1	0	.	.	.	12	12	.	.	12	.	.
Nickel	51	49	8.3	2	3.9	10	50	10	10	10	10	40
Aluminum	51	3	.	.	.	50	1800	89	260	350	550	600
Mercury	51	51	0.025	N/A	.	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Abbreviations:

N	Total number of samples.
N < RL	Number of samples less than the Division analytical reporting level (RL).
Ref	Water quality reference (standard or action level); see NC Administrative Code 15A NCAC 2B .0200.
N > Ref	Number of samples greater than (or less than) the reference.
% > Ref	Proportion (%) of samples greater than the reference.
Min	Minimum.
Max	Maximum.
N/A	Not applicable because all samples were less than the reporting level.

Units of Measurement

As noted. Conductivity = µmhos/cm; bacteria = no. colonies/100 ml; metals = µg/l; all others = mg/l.

Table 24. Summary of water quality parameters collected from Bogue Sound near Emerald Isle (Station P9600000; Class SA ORW) during the period 09/01/1994 to 08/31/1999.

Parameter	N	N < RL	Ref.	N > Ref.	% > Ref.	Min.	Max.	Percentiles 10	25	50	75	90
Field												
Temperature (^{o}C)	46	.	.	.	.	6	31	9	13	20	25	29
Conductivity	46	.	.	.	.	43	51400	36418	42100	47155	49740	50600
Dissolved Oxygen	46	.	5	0	.	5.2	11.4	5.8	6.2	7.5	8.9	10.4
pH (s.u.)	44	.	6.8; 8.5	1	2.3	6.7	8.0	7.5	7.6	7.7	7.9	8.0
Other												
Total Residue	1	0	.	.	.	75000	75000	.	.	75000	.	.
Total Sus. Solids	28	0	.	.	.	4	53	9	13	21	29	39
Hardness	41	0	.	.	.	3000	12000	4240	5500	6300	6825	7760
Chloride	43	0	.	.	.	56	39000	13400	16000	18000	33750	36200
Turbidity (NTU)	43	2	25	0	.	1.0	12.0	1.1	1.7	3.8	5.7	7.2
Bacteria												
Total coliform	0	0	.	.	.	.	.	.	.	.	.	.
Fecal coliform	43	37	200	3	7.0	1	520	10	10	10	10	10
Nutrients												
NH_3 as N	43	12	.	.	.	0.01	0.37	0.01	0.01	0.03	0.08	0.15
TKN as N	43	0	.	.	.	0.1	1.0	0.2	0.3	0.4	0.5	0.5
NO_2+NO_3 as N	43	34	.	.	.	0.01	0.13	0.01	0.01	0.01	0.01	0.02
Total Phosphorus	43	1	.	.	.	0.01	0.10	0.01	0.02	0.03	0.04	0.05
Metals (total)												
Arsenic	41	40	50	0	.	10	50	10	10	10	10	40
Cadmium	42	42	5	0	.	2	10	2	2	8	10	10
Chromium	42	42	20	0	.	25	125	25	25	25	25	100
Copper	42	33	3	4	9.5	2	11	2.0	2.0	2.0	2.0	4.6
Iron	42	6	.	.	.	50	1300	50	81	250	390	648
Lead	42	40	25	0	.	10	50	10	10	40	50	50
Manganese	2	0	.	.	.	12	18	.	12	15	18	.
Nickel	42	42	8.3	0	.	10	50	10	10	10	10	40
Aluminum	42	2	.	.	.	50	1500	110	160	300	560	1130
Mercury	42	42	0.025	N/A	.	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Abbreviations:

N	Total number of samples.
N < RL	Number of samples less than the Division analytical reporting level (RL).
Ref	Water quality reference (standard or action level); see NC Administrative Code 15A NCAC 2B .0200.
N > Ref	Number of samples greater than (or less than) the reference.
% > Ref	Proportion (%) of samples greater than the reference.
Min	Minimum.
Max	Maximum.
N/A	Not applicable because all samples were less than the reporting level.

Units of Measurement

As noted. Conductivity = µmhos/cm; bacteria = no. colonies/100 ml; metals = µg/l; all others = mg/l.

Table 25. Summary of water quality parameters collected from Back Sound at Channel Marker G '3' at Harkers Island (Station P9720000; Class SA ORW) during the period 09/01/1994 to 08/31/1999.

Parameter	N	N < RL	Ref.	N > Ref.	% > Ref.	Min.	Max.	Percentiles 10	25	50	75	90
Field												
Temperature (^{o}C)	50	.	.	.	.	3	29	9	12	18	25	28
Conductivity	50	.	.	.	.	39	52400	34025	40000	45450	49000	50700
Dissolved Oxygen	49	.	5	0	.	5.6	11.6	5.9	6.3	7.7	8.9	9.9
pH (s.u.)	49	.	6.8; 8.5	0	.	7.5	8.5	7.6	7.7	7.8	7.9	8.2
Other												
Total Residue	0	0	.	.	.	.	.	.	.	.	.	.
Total Sus. Solids	29	0	.	.	.	7	62	12	19	25	37	51
Hardness	48	0	.	.	.	2900	15000	4200	5150	6000	6800	7850
Chloride	50	0	.	.	.	88	42000	13000	16000	18500	22000	34500
Turbidity (NTU)	48	3	25	0	.	1.0	12.0	1.2	2.0	3.7	5.6	6.4
Bacteria												
Total coliform	0	0	.	.	.	.	.	.	.	.	.	.
Fecal coliform	49	48	200	0	.	1	10	10	10	10	10	10
Nutrients												
NH_3 as N	50	20	.	.	.	0.01	0.25	0.01	0.01	0.02	0.06	0.13
TKN as N	50	0	.	.	.	0.1	0.7	0.2	0.2	0.3	0.4	0.5
NO_2+NO_3 as N	50	42	.	.	.	0.01	0.06	0.01	0.01	0.01	0.01	0.01
Total Phosphorus	50	5	.	.	.	0.01	0.08	0.01	0.01	0.02	0.03	0.04
Metals (total)												
Arsenic	49	49	50	0	.	10	50	10	10	10	40	50
Cadmium	49	49	5	0	.	2	10	2	2	8	10	10
Chromium	49	49	20	0	.	25	125	25	25	25	25	100
Copper	49	37	3	4	8.2	2	280	2.0	2.0	2.0	2.0	3.0
Iron	49	3	.	.	.	50	1200	70	140	260	348	460
Lead	49	49	25	0	.	10	50	10	10	40	50	50
Manganese	2	2	.	.	.	10	10	.	10	10	10	.
Nickel	49	48	8.3	1	2.0	10	60	10	10	10	10	46
Aluminum	49	0	.	.	.	57	1700	174	260	400	570	750
Mercury	49	49	0.025	N/A	.	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Abbreviations:

N	Total number of samples.
N < RL	Number of samples less than the Division analytical reporting level (RL).
Ref	Water quality reference (standard or action level); see NC Administrative Code 15A NCAC 2B .0200.
N > Ref	Number of samples greater than (or less than) the reference.
% > Ref	Proportion (%) of samples greater than the reference.
Min	Minimum.
Max	Maximum.
N/A	Not applicable because all samples were less than the reporting level.

Units of Measurement

As noted. Conductivity = µmhos/cm; bacteria = no. colonies/100 ml; metals = µg/l; all others = mg/l.

Table 26. Summary of water quality parameters collected from Core Sound at Channel Marker R '36' near Jarrett Bay (Station P9730000; Class SA ORW) during the period 09/01/1994 to 08/31/1999.

								Percentiles				
Parameter	N	N < RL	Ref.	N > Ref.	% > Ref.	Min.	Max.	10	25	50	75	90
Field												
Temperature (^{o}C)	46	.	.	.	.	6	30	10	13	19	25	28
Conductivity	46	.	.	.	.	37	53700	26200	36100	42700	47000	50270
Dissolved Oxygen	45	.	5	0	.	5.1	11.1	5.8	6.5	7.6	9.1	10.3
pH (s.u.)	46	.	6.8; 8.5	0	.	7.5	8.4	7.5	7.6	7.8	7.9	8.1
Other												
Total Residue	0	0	.	.	.	.	.	.	.	.	.	.
Total Sus. Solids	27	0	.	.	.	9	53	11	14	18	33	40
Hardness	46	0	.	.	.	61	14000	3810	4800	5750	6600	7190
Chloride	48	0	.	.	.	4	56000	10460	14500	18000	23000	32000
Turbidity (NTU)	47	4	25	0	.	1.0	25.0	1.0	1.7	2.8	4.9	7.1
Bacteria												
Total coliform	0	0	.	.	.	.	.	.	.	.	.	.
Fecal coliform	47	46	200	0	.	1	10	10	10	10	10	10
Nutrients												
NH_3 as N	48	19	.	.	.	0.01	0.18	0.01	0.01	0.02	0.04	0.09
TKN as N	48	0	.	.	.	0.1	0.6	0.2	0.3	0.3	0.4	0.5
NO_2+NO_3 as N	48	36	.	.	.	0.01	0.05	0.01	0.01	0.01	0.01	0.02
Total Phosphorus	48	10	.	.	.	0.01	0.09	0.01	0.01	0.02	0.03	0.04
Metals (total)												
Arsenic	47	47	50	0	.	10	50	10	10	10	10	40
Cadmium	47	47	5	0	.	2	10	2	2	8	10	10
Chromium	47	47	20	0	.	25	125	25	25	25	25	85
Copper	47	40	3	5	10.6	2	45	2.0	2.0	2.0	2.0	4.6
Iron	47	9	.	.	.	50	910	50	81	190	285	358
Lead	47	47	25	0	.	10	50	10	10	40	50	50
Manganese	2	2	.	.	.	10	10	.	10	10	10	.
Nickel	47	47	8.3	0	.	10	50	10	10	10	10	40
Aluminum	47	2	.	.	.	50	1400	120	213	400	525	696
Mercury	47	47	0.025	N/A	.	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Abbreviations:

N	Total number of samples.
N < RL	Number of samples less than the Division analytical reporting level (RL).
Ref	Water quality reference (standard or action level); see NC Administrative Code 15A NCAC 2B .0200.
N > Ref	Number of samples greater than (or less than) the reference.
% > Ref	Proportion (%) of samples greater than the reference.
Min	Minimum.
Max	Maximum.
N/A	Not applicable because all samples were less than the reporting level.

Units of Measurement

As noted. Conductivity = µmhos/cm; bacteria = no. colonies/100 ml; metals = µg/l; all others = mg/l.

Table 27. Summary of water quality parameters collected from Core Sound at Channel Marker G '1' at entrance to Nelson Bay (Station P9740000; Class SA ORW) during the period 09/01/1994 to 08/31/1999.

								Percentiles				
Parameter	**N**	**N < RL**	**Ref.**	**N > Ref.**	**% > Ref.**	**Min.**	**Max.**	**10**	**25**	**50**	**75**	**90**
Field												
Temperature (^{o}C)	48	.	.	.	.	7	31	10	13	20	25	29
Conductivity	48	.	.	.	.	28	51300	24290	33550	39925	45950	48738
Dissolved Oxygen	46	.	5	.	.	5.6	11.3	6.2	7.0	8.0	9.4	10.4
pH (s.u.)	47	.	6.8; 8.5	.	.	7.2	8.4	7.6	7.7	7.8	8.0	8.1
Other												
Total Residue	0	0	.	.	.	.	.	.	.	.	.	.
Total Sus. Solids	32	0	.	.	.	4	50	6	14	20	37	46
Hardness	46	0	.	.	.	2600	14000	3220	4000	5250	6200	6800
Chloride	50	0	.	.	.	7900	42000	9800	13000	17000	23000	29500
Turbidity (NTU)	50	4	25	0	.	1.0	11.0	1.1	1.6	2.8	4.4	6.9
Bacteria												
Total coliform	0	0	.	.	.	.	.	.	.	.	.	.
Fecal coliform	49	45	200	2	4.1	1	27	10	10	10	10	10
Nutrients												
NH_3 as N	50	17	.	.	.	0.01	0.20	0.01	0.01	0.02	0.05	0.07
TKN as N	50	0	.	.	.	0.1	0.7	0.2	0.3	0.4	0.5	0.5
NO_2+NO_3 as N	50	40	.	.	.	0.01	0.14	0.01	0.01	0.01	0.01	0.05
Total Phosphorus	50	3	.	.	.	0.01	0.10	0.01	0.02	0.03	0.04	0.05
Metals (total)												
Arsenic	49	48	50	0	.	10	50	10	10	10	10	40
Cadmium	49	48	5	1	2.0	2	10	2	2	8	10	10
Chromium	49	48	20	1	2.0	25	100	25	25	25	25	80
Copper	49	38	3	5	10.2	2	8	2.0	2.0	2.0	2.0	3.1
Iron	49	12	.	.	.	50	1100	50	80	150	240	358
Lead	49	49	25	0	.	10	50	10	10	40	43	50
Manganese	1	0	.	.		19	19	.	.	19	.	.
Nickel	49	49	8.3	0	.	10	50	10	10	10	10	40
Aluminum	49	4	.	.	.	50	1800	74	175	350	493	620
Mercury	49	49	0.025	N/A	.	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Abbreviations:

N	Total number of samples.
N < RL	Number of samples less than the Division analytical reporting level (RL).
Ref	Water quality reference (standard or action level); see NC Administrative Code 15A NCAC 2B .0200.
N > Ref	Number of samples greater than (or less than) the reference.
% > Ref	Proportion (%) of samples greater than the reference.
Min	Minimum.
Max	Maximum.
N/A	Not applicable because all samples were less than the reporting level.

Units of Measurement

As noted. Conductivity = µmhos/cm; bacteria = no. colonies/100 ml; metals = µg/l; all others = mg/l.

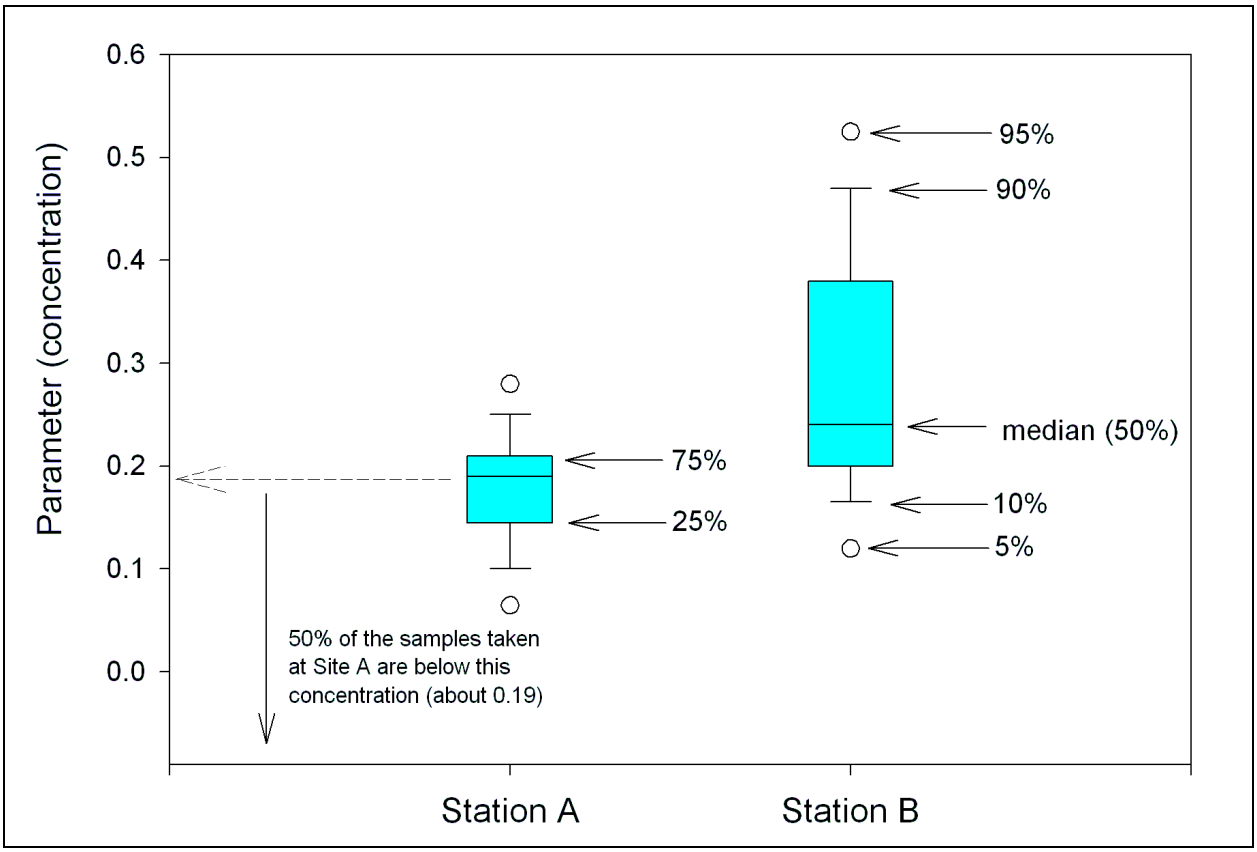

Figure 18. Explanation of box plots. Box plots (or box and whisker plots) show the distribution of measurements of a parameter. Here the distribution of measurements of a hypothetical parameter are compared between Station A and Station B. The percentage of measurements at or below a particular concentration are indicated on the figure. Note that the median and variation of measurements taken at Station B are greater than the median of Station A.

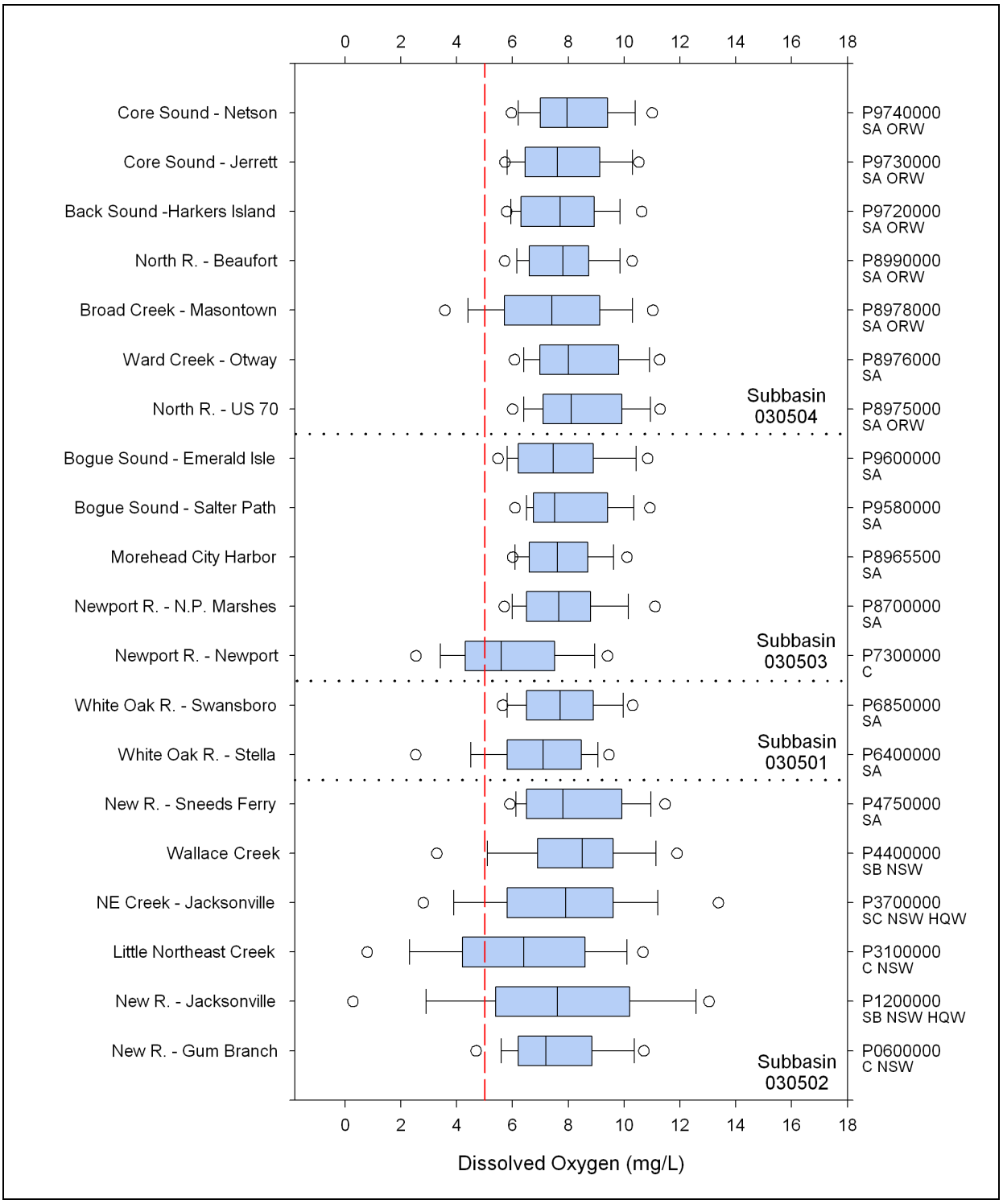

Figure 19. Box plots for dissolved oxygen in the White Oak River basin, 1980 - 1999.

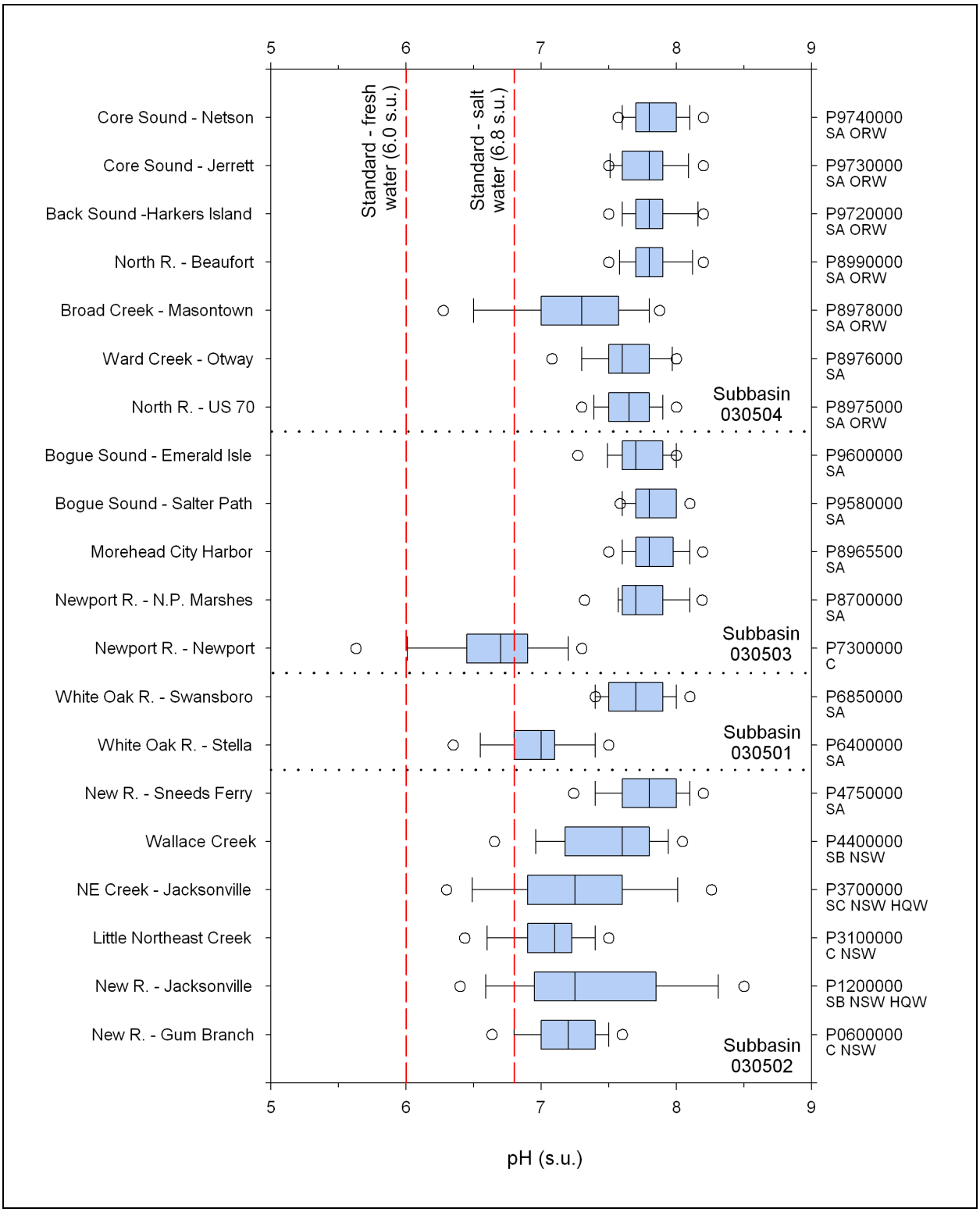

Figure 20. Box plots for pH in the White Oak River basin, 1980 - 1999.

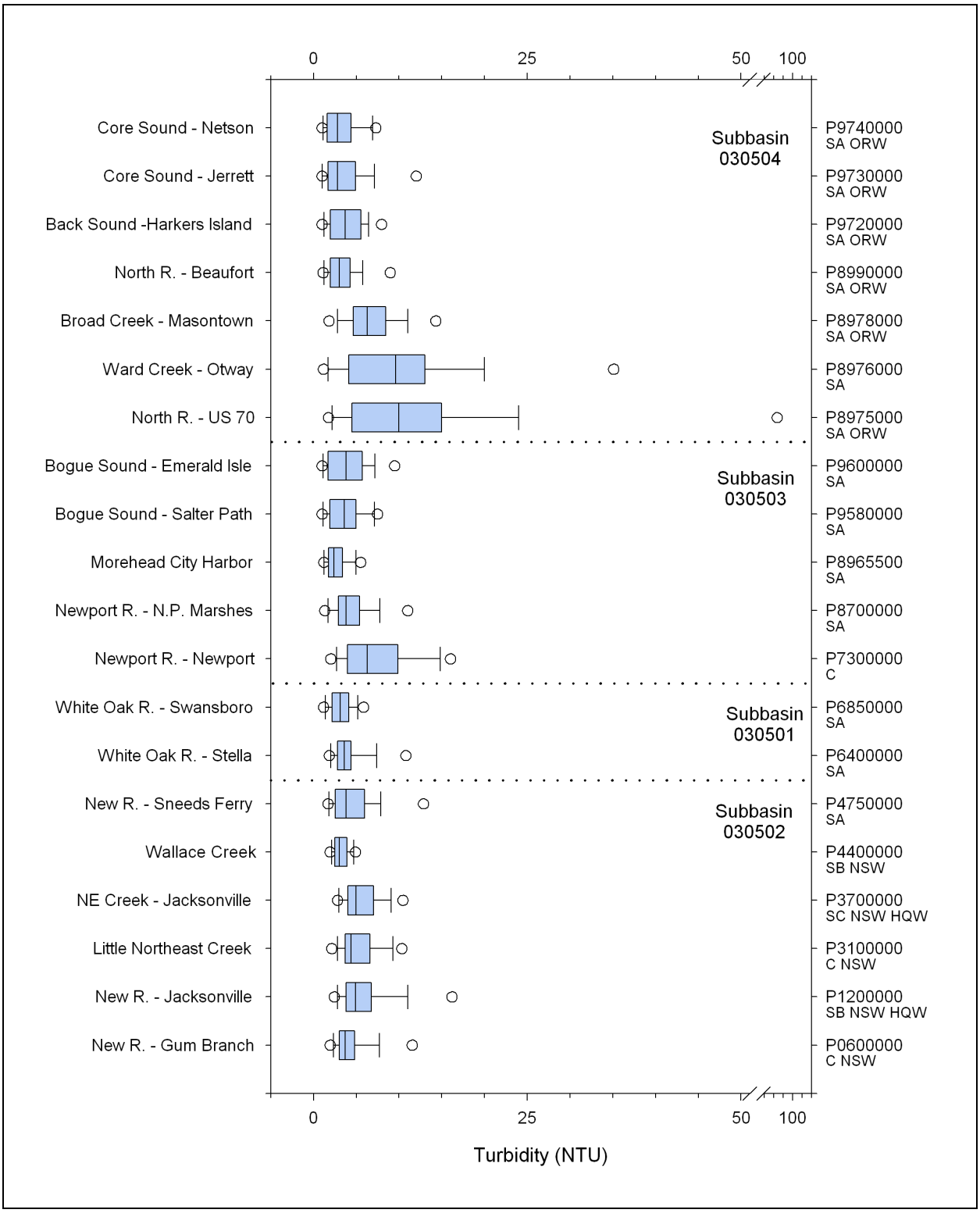

Figure 21. Box plots for turbidity in the White Oak River basin, 1980 - 1999.

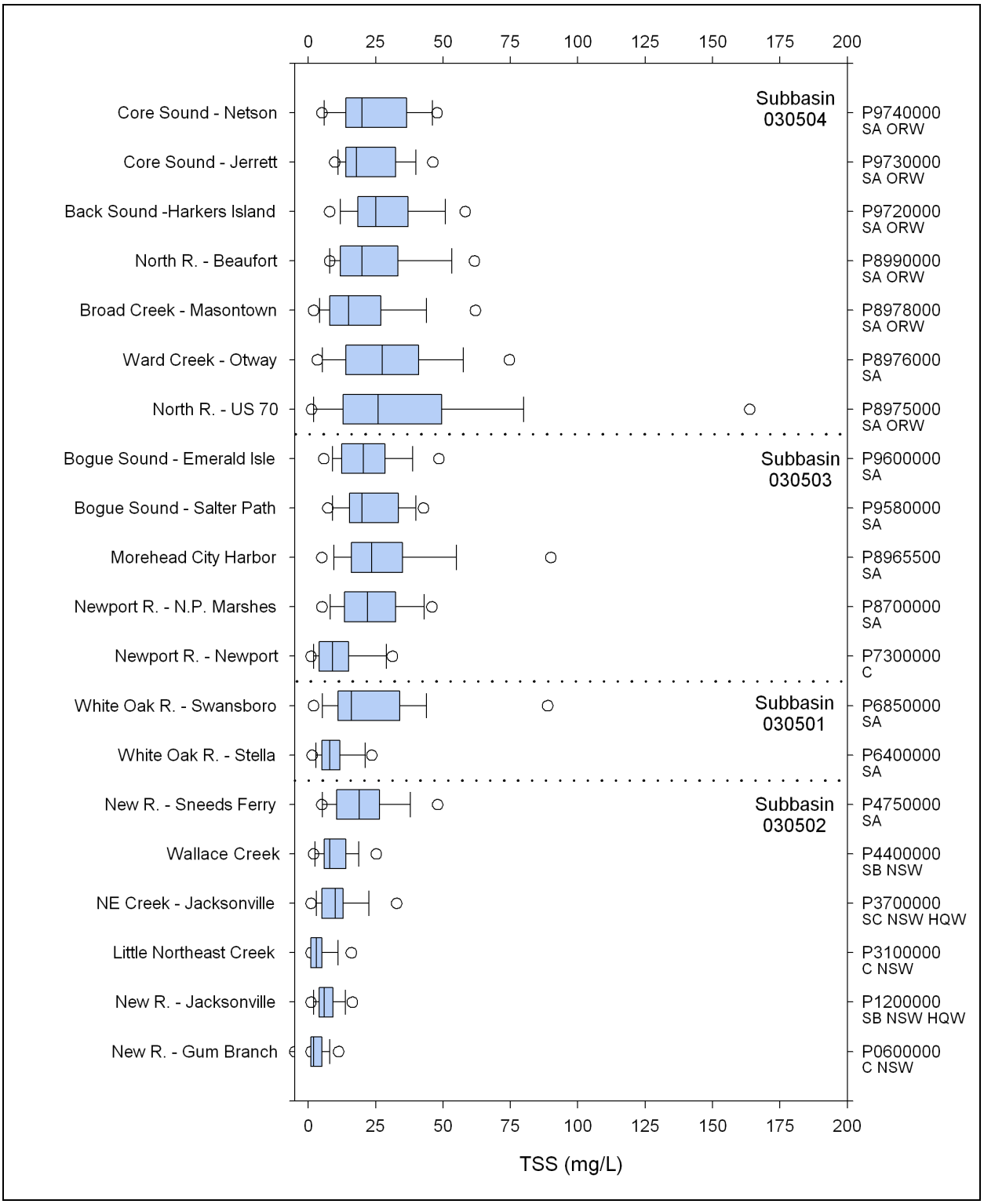

Figure 22. Box plots for total suspended solids in the White Oak River basin, 1980 - 1999.

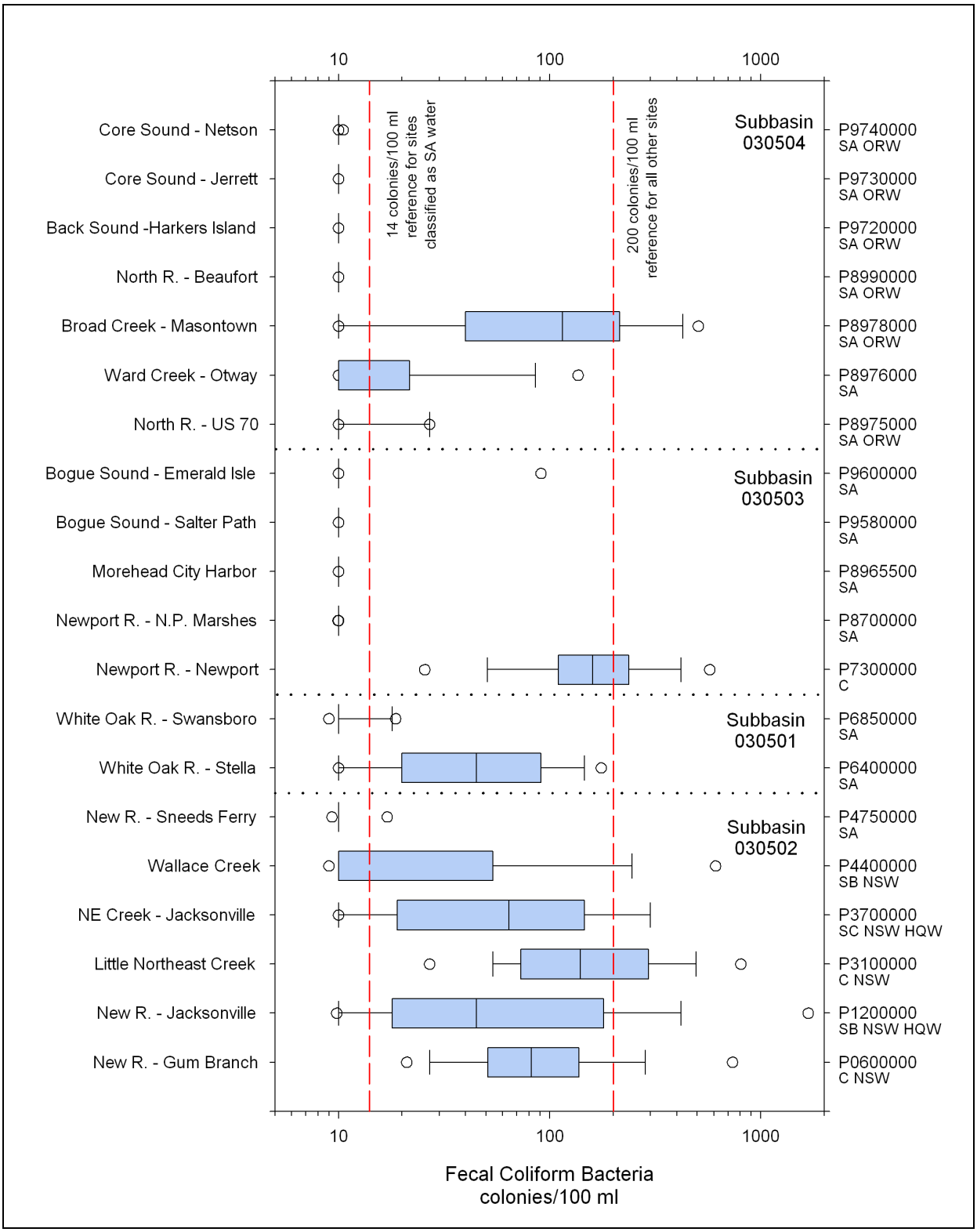

Figure 23. Box plots for total fecal coliform bacteria in the White Oak River basin, 1980 - 1999.

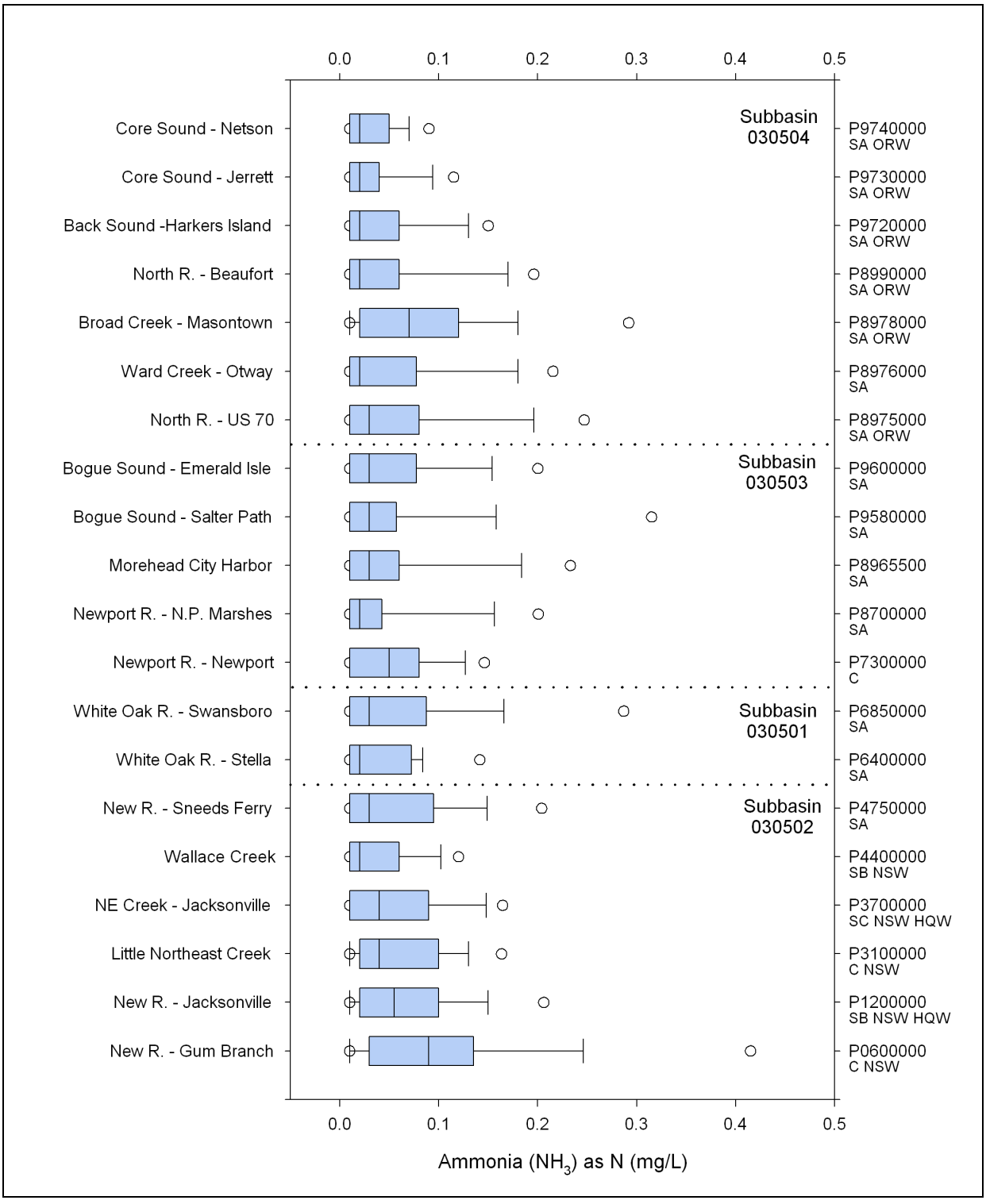

Figure 24. Box plots for ammonia as nitrogen in the White Oak River basin, 1980 - 1999.

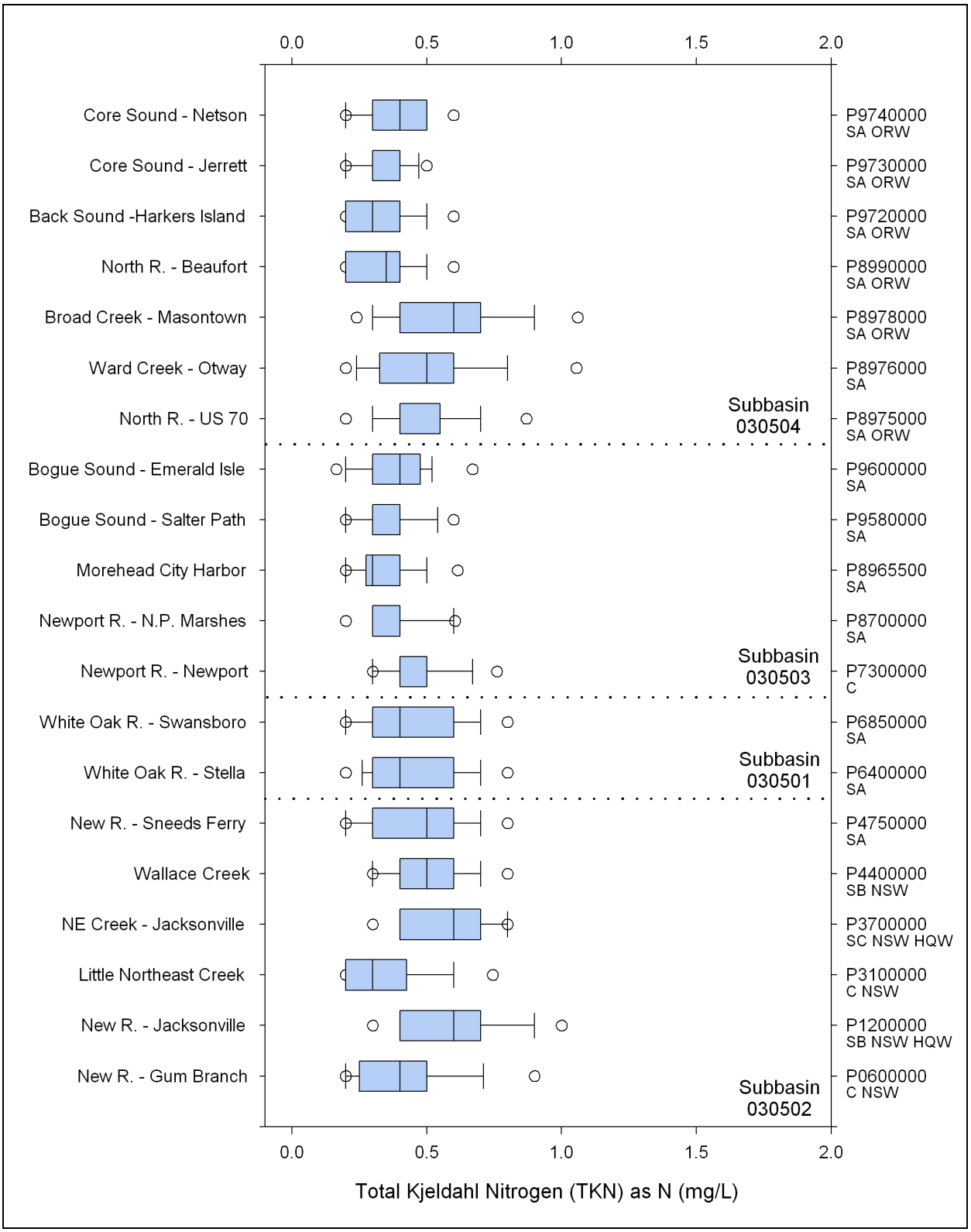

Figure 25. Box plots for total Kjeldahl nitrogen in the White Oak River basin, 1980 - 1999.

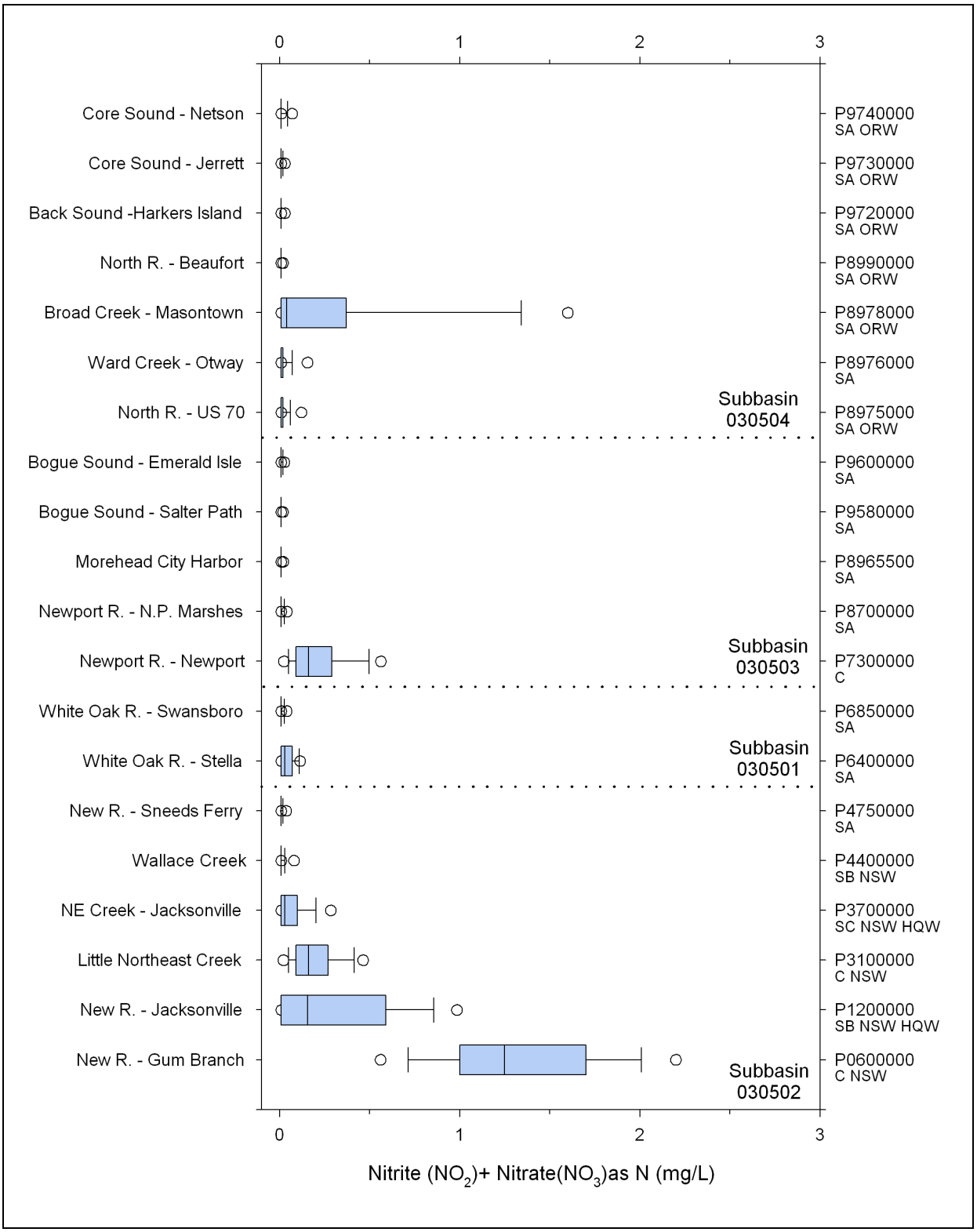

Figure 26. Box plots for nitrite + nitrate as nitrogen in the White Oak River basin, 1980 - 1999.

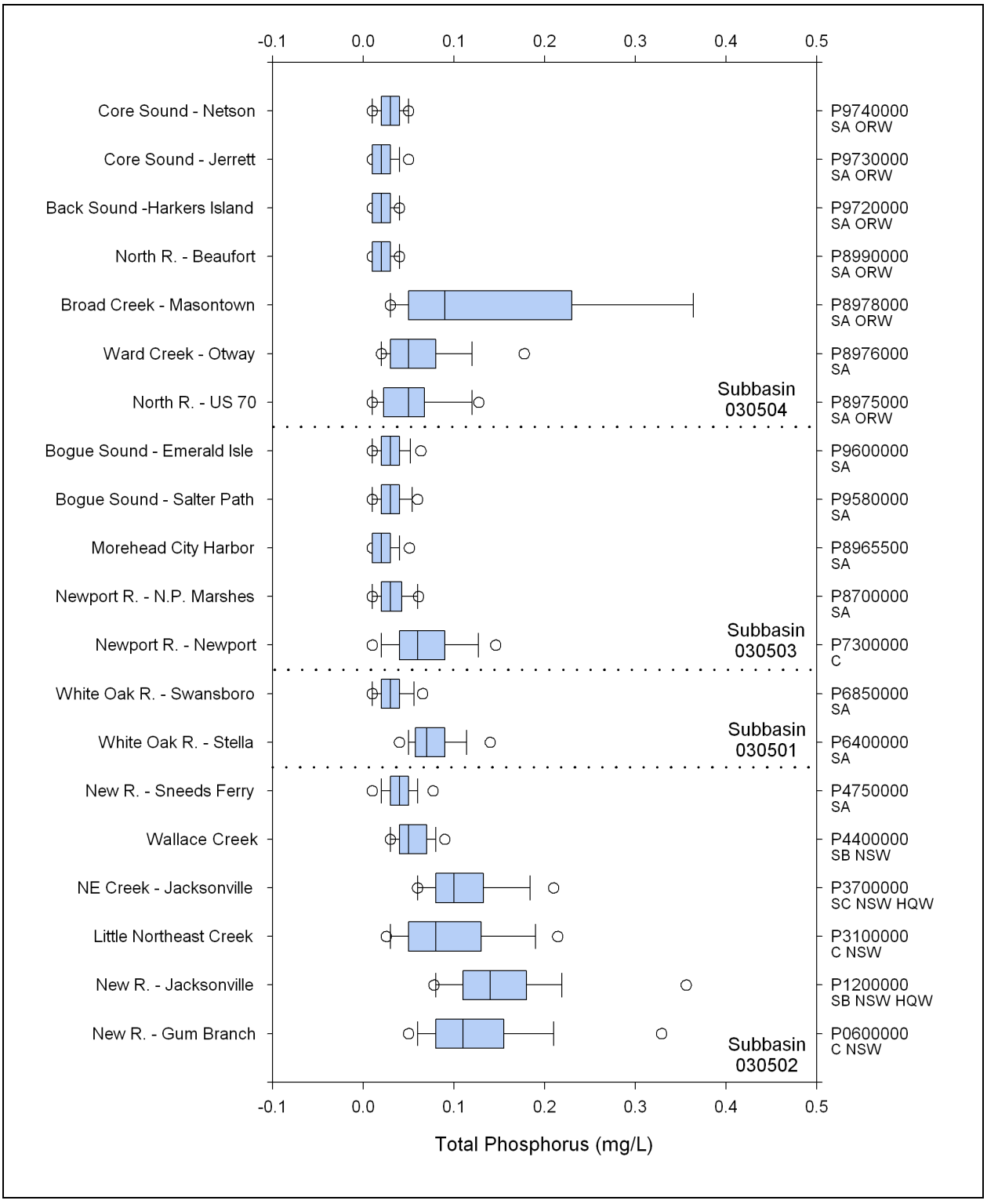

Figure 27. Box plots for total phosphorus in the White Oak River basin, 1980 - 1999.

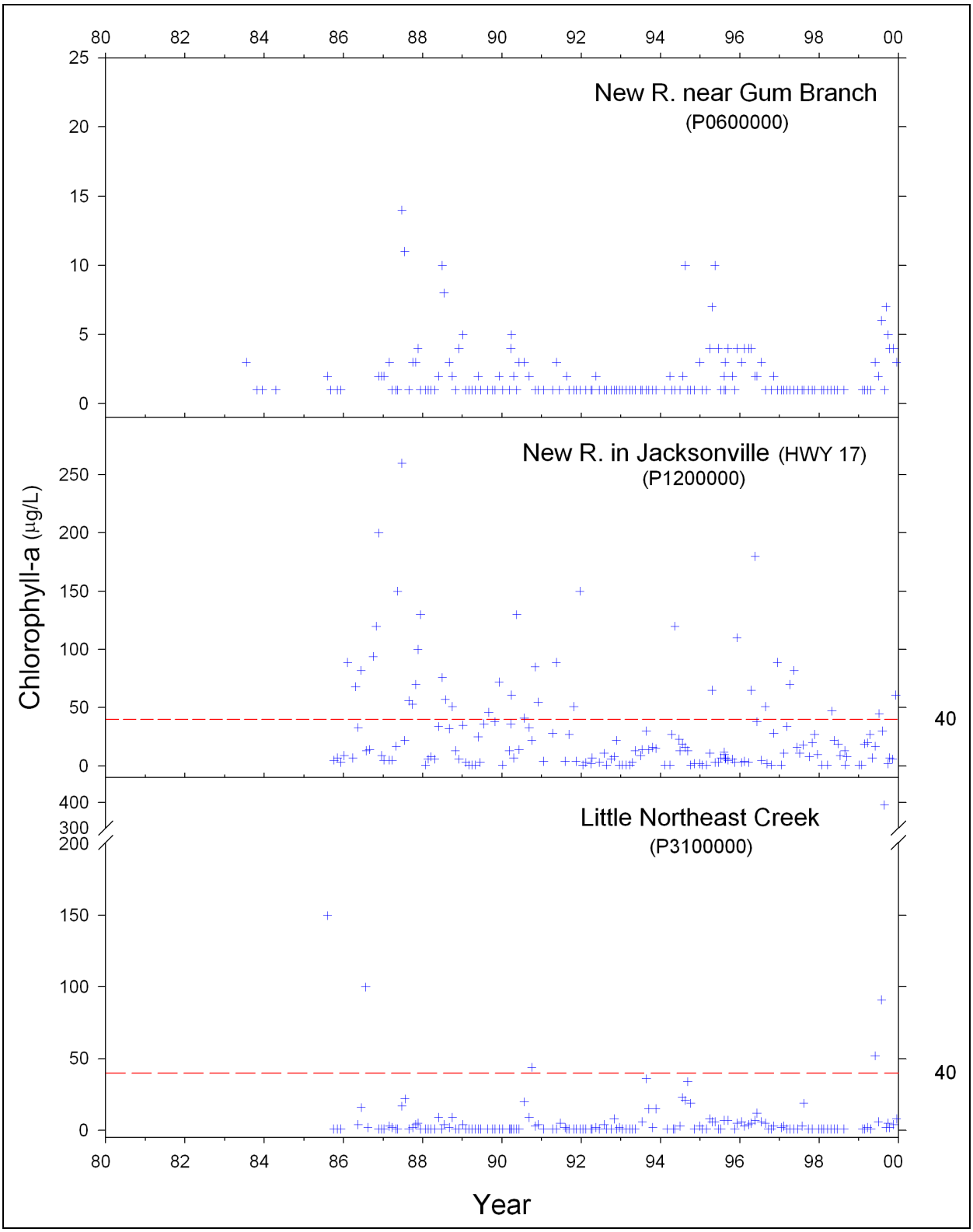

Figure 28. **Temporal patterns for chlorophyll *a* at select sites in the White Oak River basin. Note: the scaling of the Y axis varies among plots.**

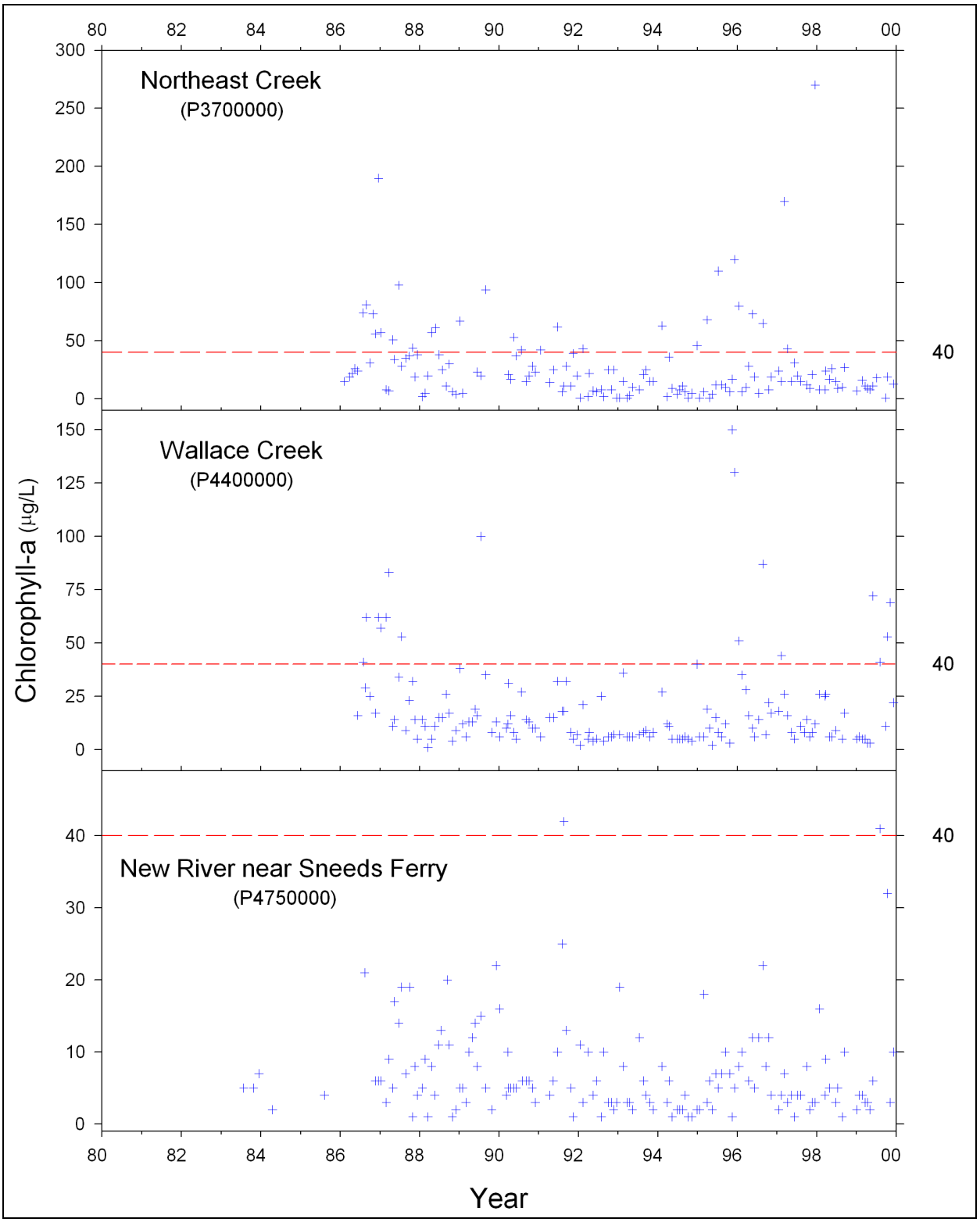

Figure 28. (continued).

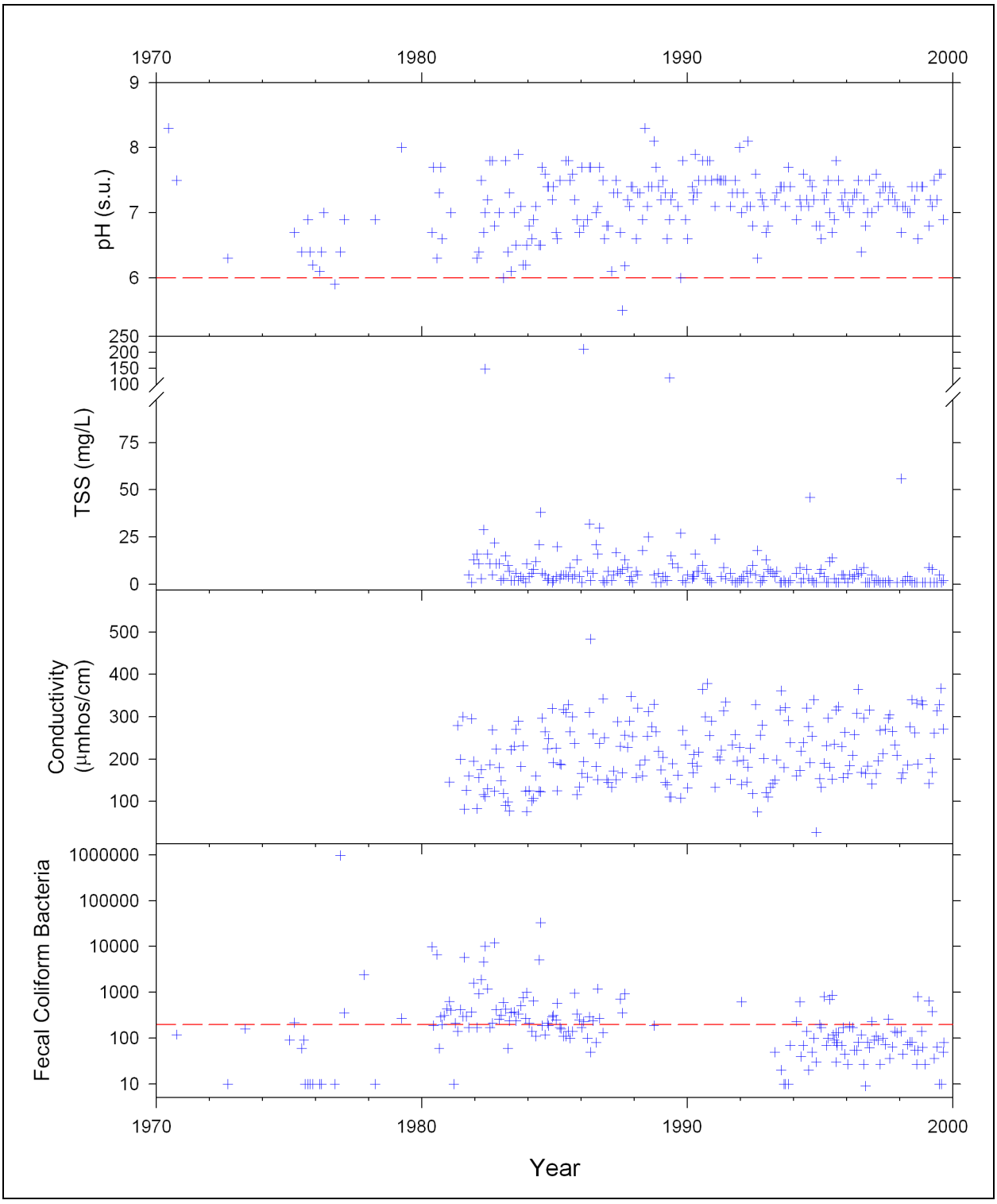

Figure 29. Temporal patterns for pH, total suspended solids (TSS), conductivity, and fecal coliform bacteria at the New River near Gum Branch.

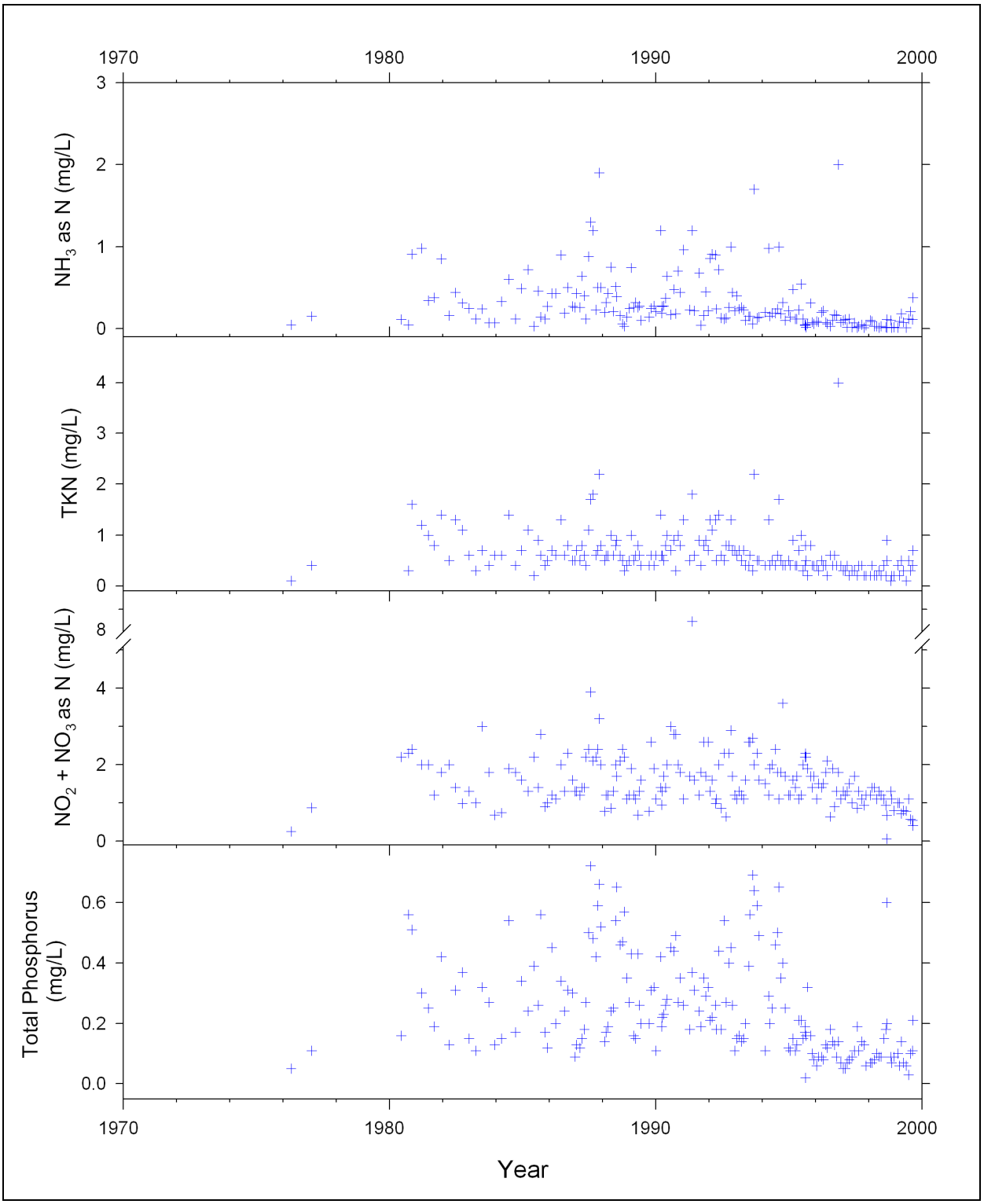

Figure 30. Temporal patterns for ammonia as nitrogen (NH_3), total Kjeldahl nitrogen, nitrite + nitrate (NO_2+NO_3) as nitrogen, and total phosphorus at the New River near Gum Branch.

AQUATIC TOXICITY MONITORING

Seven facility permits in the White Oak River basin currently require whole effluent toxicity (WET) monitoring with a limit (Figure 31 and Table 28). The USMC Camp Lejeune Hadnot Pt/001, Tarawa Terrace, and Camp Johnson facilities are currently inactive.

The compliance rates of these facilities have fluctated over time, but since 1993, have stabilized at approximately 95-100% (Table 29 and Figure 32).

The discharges located at the USMC Camp Lejeune base were consolidated into the Hadnot Pt. 002 outfall in October of 1998. Prior to then, some of the discharges experienced toxicity problems associated with excess total residual chlorine from the time they initiated monitoring in 1990 until mid-1992. Since consolidating the Camp Johnson, Hadnot Point 001, and the Tarawa Terrace discharges, the Hadnot Point 002 facility has been in compliance with its permit limits.

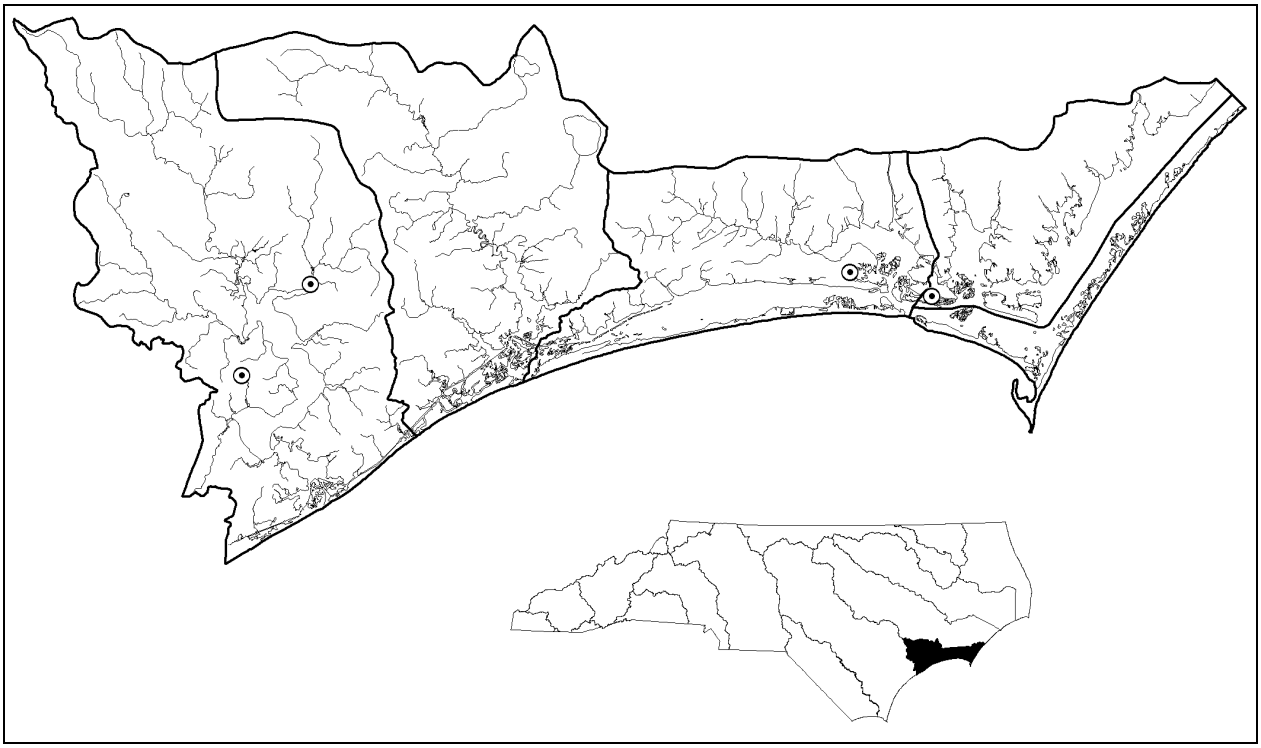

Figure 31. Location of facilities required to perform toxicity testing in the White Oak River basin.

Table 28. Facilities in the White Oak River basin required to perform whole effluent toxicity testing.

Subbasin/Facility	NPDES#	Receiving Stream	County	Flow (MGD)	IWC (%)	7Q10
02						
USMC Camp Lejeune-Camp Johnson WWTP	NC0063011/001	Northeast Cr	Onslow	1.0	N/A	Tidal
USMC Camp Lejeune-Hadnot Pt WWTP 001	NC0063029/001	New R	Onslow	8.0	42	Tidal
USMC Camp Lejeune-Hadnot Pt WWTP 002	NC0063029/002	New R	Onslow	15.0	N/A	Tidal
USMC Camp Lejeune-Tarawa Terrace WWTP	NC0063002/001	Northeast Cr	Onslow	1.25	N/A	Tidal
Weston Inc.-ABC One Hour Cleaners	NC0084395/001	Northeast Cr	Onslow	0.216	90	Tidal
03						
Beaufort WWTP	NC0021831/001	Taylor Cr	Carteret	1.5	N/A	Tidal
Morehead City WWTP	NC0026611/001	Calico Cr	Carteret	1.7	N/A	Tidal

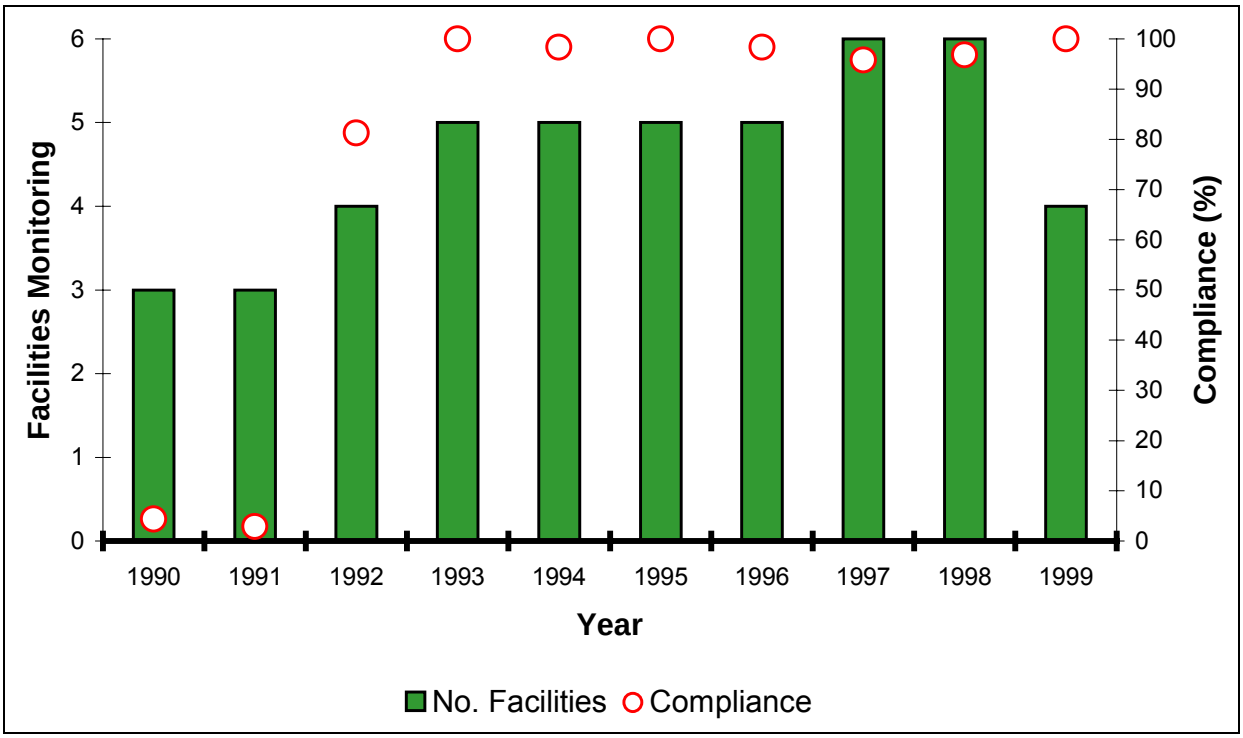

Figure 32. Compliance record of facilities in the White Oak River basin required to perform whole effluent toxicity testing, 1990 - 1999. The compliance values were calculated by determining whether a facility was meeting its ultimate permit limit during the given time period, regardless of any SOCs in force.

Table 29. Compliance record of facilities performing whole effluent toxicity testing in the White Oak River basin.

Subbasin/Facility	NPDES#	Pre 1999 Passes[1]	Pre 1999 Fails	1999 Passes	1999 Fails
02					
USMC Camp Lejeune-Camp Johnson WWTP[2]	NC0063011/001	28	23	0	0
USMC Camp Lejeune-Hadnot Pt WWTP 001[2]	NC0063029/001	28	21	0	0
USMC Camp Lejeune-Hadnot Pt WWTP 002	NC0063029/002	8	0	4	0
USMC Camp Lejeune-Tarawa Terrace WWTP[2]	NC0063002/001	26	22	0	0
Weston Inc.-ABC One Hour Cleaners	NC0084395/001	0	0	3	0
03					
Beaufort WWTP	NC0021831/001	28	0	4	0
Morehead City WWTP	NC0026611/001	22	6	4	0

[1]Note that "pass" denotes meeting a permit limit or, for those facilities with a monitoring requirement, meeting a target value. The actual test result may be a "pass" (from a pass/fail acute or chronic test), LC_{50}, or chronic value. Conversely, "fail" means failing to meet a permit limit or target value.
[2]Facility inactive since October, 1998.

REFERENCES

Baker Environmental, Inc. 1997. Personal communication. Coreopolis, PA.

Balthis, W. L., J. L. Hyland and T. R. Snoots. 1998. Compendium of environmental data from estuaries sampled in the North Carolina portion of the EMAP Carolinian Province during summer 1994-1996. National Oceanic and Atmospheric Administration. 62pp.

Burkholder, J. M. and H. B. Glasgow, Jr. 1997. *Pfiesteria piscicida* and other *Pfiesteria*-like dinoflagellates: Behavior, impacts, and environmental controls. Limnology and Oceanography. 42: 1052-1075.

_____, and E. K. Hannon. 1998. The toxic *Pfiesteria* complex vs. mistaken identities. 5 pp. (unpublished). North Carolina State University, Raleigh, NC.

Burkholder, J. M., M. A. Mallin, H.B. Glasgow, Jr., L. M. Larsen, M. R. McIver, G. C. Shank, N. Deamer-Melia, D. S. Briley, J. Springer, B. W. Touchettte and E. K. Hannon. 1997 Impacts to a coastal river and estuary from rupture of a swine waste holding lagoon. J. Envir. Qual. 26: 1451-1466.

Eaton, L. E. (*in press*). Development and validation of biocriteria using benthic macroinvertebrates for North Carolina estuarine waters. Marine Pollution Bulletin.

_____, D. Farrell, G. J. Guillen, W. G. Nelson and G. Gibson. (*in press*). Chapter 11 Case Studies. *In* Estuarine and coastal marine waters bioassessment and biocriteria technical guidance. US EPA. 289pp.

LeGrand, H. E. and S. P. Hall. 1997. Natural Heritage Program list of the rare animal species of North Carolina. North Carolina Natural Heritage Program, Division of Parks and Recreation, North Carolina Department of Environment, Health, and Natural Resources. Raleigh, NC. 82 pp.

Menhinick, E. F. 1991. The freshwater fishes of North Carolina. North Carolina Wildlife Resources Commission. Raleigh, NC. 227 pp.

_____ and A. L. Braswell (eds). 1997. Endangered, threatened, and rare fauna of North Carolina. Part IV. A reevaluation of the freshwater fishes. Occas. Pap. N.C. State Mus. Nat. Sci. and N.C. Biol. Surv. No. 11. Raleigh, NC.

NCDEHNR. 1990. New River, Onslow County: nutrient control measures and water quality characteristics for 1986-1989. DEM Water Quality Report No. 90-04, June 1990. North Carolina Department of Environment, Health, and Natural Resources. Division of Environmental Management. Water Quality Section. Raleigh, NC.

_____. 1992. Biological Monitoring. Environmental Sciences Branch; Ecosystems Analysis Unit; Biological Assessment Group. April 1992. North Carolina Department of Environment, Health, and Natural Resources. Division of Environmental Management. Water Quality Section. Raleigh, NC.

_____. 1995. White Oak River basin. Basinwide assessment report support document. Environmental Sciences Branch. North Carolina Department of Environment, Health, and Natural Resources. Division of Environmental Management. Water Quality Section. Raleigh, NC.

_____. 1996a. Report of sanitary survey Bear Creek area D-1, May 1992 - January 1996. North Carolina Department of Environment, Health, and Natural Resources. 36pp.

_____. 1996b. Report of sanitary survey Deer Creek area D-4, October 1992 - January 1996. *Ibid*. 41pp.

REFERENCES (continued)

_____. 1996c. Report of sanitary survey Sneads Ferry area C-2, June 1993 - April 1996. *Ibid*. 54pp.

_____. 1997a. Standard operating procedures. Biological Monitoring. Environmental Sciences Branch. Ecosystems Analysis Unit. Biological Assessment Group. North Carolina Department of Environment, Health, and Natural Resources. Division of Water Quality. Water Quality Section. Raleigh, NC.

_____. 1997b. Summary of water quality effects of the 1996 hurricanes in North Carolina. North Carolina Department of Environment, Health, and Natural Resources. Division of Water Quality. Water Quality Section. Raleigh, NC. 55pp.

NCDENR. 1998a. Report of sanitary survey Queens Creek area D-2, April 1995 - March 1998. North Carolina Department of Environment and Natural Resources. 35pp.

_____. 1998b. Report of sanitary survey Bogue Sound area E-2, March 1993 - November 1997. *Ibid*. 52pp.

_____. 1998c. Report of sanitary survey Chadwick Bay area C-1, November 1995 - June 1998. *Ibid*. 25pp.

_____. 1998d. Report of sanitary survey Stones Bay area C-3, July 1989 - May 1998. *Ibid*. 25pp.

_____. 1998e. Report of sanitary survey Bogue Sound area E-2, March 1993 - November 1997. *Ibid*. 50pp.

_____. 1998f. Report of sanitary survey Newport River area E-4, April 1996 - June 1998. *Ibid*. 39pp.

_____. 1998g. Report of sanitary survey North River area E-6, May 1995 - March 1998. *Ibid*. 42pp.

_____. 1998h. Report of sanitary survey Back Sound area E-7, September 1993- July 1998. *Ibid*. 26pp.

_____. 1998i. Report of sanitary survey Core Sound areas E-8 and E-9, July 1995 - April 1998. *Ibid*. 48pp.

_____. 1998j. Report of sanitary survey West Bay/Cedar Island area F-3 and F-4, June 1990 - May 1998. *Ibid*. 37pp.

_____. 1998k. Report of sanitary survey Back Sound area E-7, September 1993 - July 1998. *Ibid*. 26pp.

_____. 1998l. Report of sanitary survey Core Sound areas E-8 and E-9, July 1995 - April 1998. *Ibid*. 48pp.

_____. 1998m. Report of sanitary survey West Bay/Cedar Island area F-3 and F-4, June 1990 - May 1998. *Ibid*. 37pp.

_____. 1998n. Standard operating procedures for phytoplankton sampling and enumeration. July 1998 (draft). North Carolina Department of Environment and Natural Resources. Division of Water Quality; Water Quality Section. Raleigh, NC.

_____. 1999a. Annual report of fish kill events. North Carolina Department of Environment and Natural Resources. Division of Water Quality. Water Quality Section. Environmental Sciences Branch. Raleigh, NC.

_____. 1999b. Report of sanitary survey White Oak River area D-3, August 1995 - December 1998. North Carolina Department of Environment and Natural Resources. 43pp.

REFERENCES (continued)

_____. 1999c. Report of sanitary survey Broad Creek area E-1, March 1994 - January 1999. *Ibid*. 39pp.

_____. 1999d. Report of sanitary survey Hurst Beach area C-4, November 1994 - August 1999. *Ibid*. 26pp.

_____. 1999e. Report of sanitary survey Morehead City-Atlantic Beach area E-3, August 1994 - January 1999. *Ibid*. 62pp.

_____. 1999f. Report of sanitary survey Taylor Creek area E-5, April 1995 - May 1999. *Ibid*. 45pp.

USEPA. 1995. Guidance for assessing chemical contaminant data for use in fish advisories. Vol. 1: Fish sampling and analysis. 2nd Edition. Washington, D.C. Office of Science and Technology. EPA 823-R-95-007.

USFDA. 1980. Action levels for poisonous or deleterious substances in human food and animal feed. Shellfish Sanitation Branch, Washington, D. C.

GLOSSARY

7Q10	A value which represents the lowest average flow for a seven day period that will recur on a ten year frequency. This value is applicable at any point on a stream. 7Q10 flow (in cfs) is used to allocate the discharge of toxic substances to streams.
Bioclass	Criteria have been developed to assign bioclassifications ranging from Poor to Excellent to each benthic sample based on the number of taxa present in the intolerant groups (EPT) and the Biotic Index value.
cfs	Cubic feet per second, generally the unit in which stream flow is measured.
CHL *a*	Chlorophyll *a*.
Class C Waters	Freshwaters protected for secondary recreation, fishing, aquatic life including propagation and survival, and wildlife. All freshwaters shall be classified to protect these uses at a minimum.
Conductivity	In this report, synonymous with specific conductance and reported in the units of μmhos/cm at 25 ^{o}C. Conductivity is a measure of the resistance of a solution to electrical flow. Resistance is reduced with increasing content of ionized salts.
Division	The North Carolina Division of Water Quality.
D.O.	Dissolved Oxygen.
Ecoregion	An area of relatively homogeneous environmental conditions, usually defined by elevation, geology, and soil type. Examples include mountains, piedmont, coastal plain, sandhills, and slate belt.
EPT	The insect orders (Ephemeroptera, Plecoptera, Trichoptera); as a whole, the most intolerant insects present in the benthic community.
EPT N	The abundance of Ephemeroptera, Plecoptera, Trichoptera insects present, using values of 1 for Rare, 3 for Common and 10 for Abundant.
EPT S	Taxa richness of the insect orders Ephemeroptera, Plecoptera and Trichoptera. Higher taxa richness values are associated with better water quality.
HQW	High Quality Waters. Waters which are rated as excellent based on biological and physical/chemical characteristics through Division monitoring or special studies, . . . primary nursery areas designated by the Marine Fisheries Commission, . . . and all Class SA waters.
IWC	Instream Waste Concentration. The percentage of a stream comprised of an effluent calculated using permitted flow of the effluent and 7Q10 of the receiving stream.
Major Discharger	Greater than or equal to one million gallons per day discharge (≥ 1 MGD).
MGD	Million Gallons per Day, generally the unit in which effluent discharge flow is measured.
Minor Discharger	Less than one million gallons per day discharge (< 1 MGD).
NPDES	National Pollutant Discharge Elimination System.

GLOSSARY (continued)

NCBI (EPT BI)	North Carolina Biotic Index, EPT Biotic Index. A summary measure of the tolerance values of organisms found in the sample, relative to their abundance. Sometimes noted as the NCBI or EPT BI.
NCIBI	North Carolina Index of Biotic Integrity (NCIBI); a summary measure of the effects of factors influencing the fish community.
NSW	Nutrient Sensitive Waters. Waters subject to growths of microscopic or macroscopic vegetation requiring limitations on nutrient inputs.
NTU	Nephelometric Turbidity Unit.
ORW	Outstanding Resource Waters. Unique and special waters of exceptional state or national recreational or ecological significance which require special protection to maintain existing uses.
Parametric Coverage	A listing of parameters measured and reported.
SA Waters	Suitable for commercial shellfishing and all other tidal saltwaters uses.
SB Waters	Saltwaters protected for primary recreation which includes swimming on a frequent or organized basis and all Class SC waters.
SC Waters	Saltwaters protected for secondary recreation, fishing, aquatic life including propagation and survival, and wildlife. All saltwaters shall be classified to protect these uses at a minimum.
SOC	A consent order between an NPDES permittee and the Environmental Management Commission that specifically modifies compliance responsibility of the permittee, requiring that specified actions are taken to resolve non-compliance with permit limits.
Total S (or S)	The number of different taxa present in a benthic macroinvertebrate sample.
UT	Unnamed tributary.
WWTP	Wastewater treatment plant.
Web Sites	Basinwide planning -- http://h2o.enr.state.nc.us/basinwide/basinwide/default.html
	Biological monitoring -- http://www.esb.enr.state.nc.us/bau.html
	Fish consumption advisories -- http://www.schs.state.nc.us/epi/fish/
	Fish kills -- http://www.esb.enr.state.nc.us/fishkill/fishkill00.html
	King mackerel advisory – http://www.ncfisheries.net/news/kingmack.htm
	North Carolina Administrative Code that relates to the Division of Water Quality and water quality protection -- http://h2o.enr.state.nc.us/rules/ruleindex.html
	Pfiesteria – http://www.schs.state.nc.us/epi/fpfie.cfm
	Shellfish sanitation – http://www.deh.enr.state.nc.us/shellfish/new/index.htm

Appendix B1. Benthic macroinvertebrate sampling methods and criteria.

Freshwater wadeable and flowing waters

Benthic macroinvertebrates can be collected from wadeable, freshwater, flowing waters using two sampling procedures. The Division of Water Quality's standard qualitative sampling procedure includes 10 composite samples: two kick-net samples, three bank sweeps, two rock or log washes, one sand sample, one leafpack sample, and visual collections from large rocks and logs (NCDEHNR 1997). The purpose of these collections is to inventory the aquatic fauna and produce an indication of relative abundance for each taxon. Organisms are classified as Rare (1-2 specimens), Common (3-9 specimens), or Abundant (≥ 10 specimens).

Several data-analysis summaries (metrics) can be produced from standard qualitative samples to detect water quality problems (Table B1).

Table B1. Benthos classification criteria for freshwater wadeable and flowing water systems in the coastal plain ecoregion.

Metric	Sample type	Bioclass	Score
EPT S	10-sample Qualitative	Excellent	> 27
		Good	21 - 27
		Good-Fair	14 - 20
		Fair	7 - 13
		Poor	0 - 6
	4-sample EPT	Excellent	> 23
		Good	18 - 23
		Good-Fair	12 - 17
		Fair	6 –11
		Poor	0 - 5
Biotic Index (range 0 – 10)	10-sample Qualitative	Excellent	< 5.47
		Good	5.47 - 6.05
		Good-Fair	6.06 - 6.72
		Fair	6.73 - 7.73
		Poor	> 7.73

These metrics are based on the idea that unstressed streams and rivers have many invertebrate taxa and are dominated by intolerant species. Conversely, polluted streams have fewer numbers of invertebrate taxa and are dominated by tolerant species. The diversity of the invertebrate fauna is evaluated using taxa richness counts; the tolerance of the stream community is evaluated using a biotic index.

EPT taxa richness (EPT S) is used with DWQ criteria to assign water quality ratings (bioclassifications). "EPT" is an abbreviation for Ephemeroptera + Plecoptera + Trichoptera, insect groups that are generally intolerant of many kinds of pollution. Higher EPT taxa richness values usually indicate better water quality. Water quality ratings also are based on the relative tolerance of the macroinvertebrate community as summarized by the North Carolina Biotic Index (NCBI).

Both tolerance values for individual species and the final biotic index values have a range of 0-10, with higher numbers indicating more tolerant species or more polluted conditions. Water quality ratings assigned with the biotic index numbers are combined with EPT taxa richness ratings to produce a final bioclassification, using criteria for coastal plain streams. EPT abundance (EPT N) and total taxa richness calculations also are used to help examine between-site differences in water quality. If the EPT taxa richness rating and the biotic index differ by one bioclassification, the EPT abundance value is used to determine the final site rating.

Benthic macroinvertebrates can also be collected using an EPT sampling procedure. Four rather than 10 composite qualitative samples are taken at each site: 1 kick, 1 sweep, 1 leafpack and visual collections. Only EPT groups are collected and identified, and only EPT criteria are used to assign a bioclassification.

Both EPT taxa richness and biotic index values also can be affected by seasonal changes. DWQ criteria for assigning bioclassification are based on summer sampling: June - September. For samples collected outside summer, EPT taxa richness can be adjusted by subtracting out winter/spring Plecoptera or other adjustment based on resampling of summer site. The biotic index values also are seasonally adjusted for samples outside the summer season.

Criteria have been developed to assign bioclassifications ranging from Poor to Excellent to each benthic sample. These bioclassifications primarily reflect the influence of chemical pollutants. The major physical pollutant, sediment, is not assessed as well by a taxa richness analysis.

Freshwater nonwadeable and flowing waters

Deep (nonwadeable) coastal rivers with little or no visible current have different EPT criteria (Coastal B) that are being used on a provisional basis until more data can be gathered.

Swamp streams
Swamp streams are located in the coastal plain area and cease flowing during summer low-flow periods. This seasonal interruption in flow limits the diversity of the fauna, requiring special criteria to properly rate such streams. The swamp stream sampling method utilizes a variety of collection techniques to inventory the macroinvertebrate fauna at a site. A total of nine sweep samples (one series of three by each field team member) are collected from each of the following habitat types: macrophytes, root mats/undercut banks, and detritus deposits. If one of these habitat types is not present, a sweep from one of the other habitats should be substituted. A sweep for the swamp method is defined as the area that can be reached from a given standing location. Three log/debris washes also are collected. Visual collections are the final technique used at each site.

Samples are picked on site. The primary output for this sampling method is a taxa list with an indication of relative abundance (Rare, Common, or Abundant) for each taxon. Sampling during winter flow periods provides the best opportunity for detecting impacts, and only winter benthos (February - March) data can be used to evaluate swamp streams.

Scoring System -- A multi-metric system was developed to evaluate swamp streams, using the NC Biotic Index (NCBI), habitat score, total taxa richness (S), and EPT abundance (EPT N). The system was developed using data from the Lumber, White Oak, Cape Fear, Neuse, and Tar river basins. Scores of 5, 3, or 1 were assigned for each metric. Since EPT abundance and the NCBI have greater sensitivity to changes in water quality, these scores are given greater weight by multiplying their scores by 2:

Site Score = 2*(NCBI score) + 2*(EPT N score) + S score + Habitat score

This gives a maximum site score of 30 and minimum site score of 6. Higher scores indicate better benthic communities.

Swamp streams were divided into two broad types: Streams with a distinct channel (C) and stream with a braided channel (B). Both EPT abundance and total taxa richness are expected to be lower in braided swamp streams, and require application of a correction factor before applying the swamp criteria (+8 for total taxa richness, +10 for EPT abundance).

Stream pH also affects these metrics, and scoring criteria are adjusted for all sites with pH <5.5.

Estuaries
Shallow (< 1.5 m) estuarine waters are sampled using a D-frame dip net with a 600 - 700 µm mesh bag. All available subtidal benthic habitats were swept for a total of ten minutes. Some elutriation of the sample usually took place in the field to reduce sample volume, then the sample was preserved in 10% formalin with rose bengal added as a tissue stain.

At the laboratory, macroinvertebrates were separated from the sediment by visual examination. Macroinvertebrates were identified to the lowest practical taxonomic level, usually species. Abundance was recorded semi-quantitatively, with only a general indication of a taxon's abundance: Rare = 1 - 2; Common = 3 - 9; Abundant = 10 – 29; Very Abundant = 30 – 99; and Dominant > 100. No more than 100 individuals of any taxon were counted since the presence of a greater number of individuals of a particular taxa at a site was no more informative, but much more costly to enumerate.

A biotic index is calculated from the individual taxon's sensitivity values (ranging from 1 to 5) and weighted for abundance using a formula commonly used in calculating freshwater biotic indices (Chutter 1972, Hilsenhoff 1977, Lenat 1993):

$$BI = (\sum SV_i * N_i)/\text{Total N}$$

where SV_i is the sensitivity value of the i^{th} taxa, N_i is the abundance of the i^{th} taxa and Total N is the number of individuals in the sample. A high Estuarine Biotic Index (E BI) value indicates many intolerant taxa and good water quality at a location, while a low EBI is indicative of stressed conditions.

Amphipoda and Caridean shrimp taxa richness, as well as Total taxa richness, also are used to assess between-site differences. Many species at a location, particularly pollution intolerant taxa, indicate healthy conditions, while few species at a site indicate stressed conditions (Eaton, in press).

A total score is assigned to a body of water based on the values of these three metrics. The score is derived by following these four steps:

1. Assign points for each of three metrics from a sweep sample (Table B2).

2. Sum points. This will yield a number between 3 and 15 with 15 suggesting the least stressed community.

3. Check for Bonus Point conditions. Add 2 points to score if one or more of the conditions occurred:
   - homogeneous habitat,
   - consistently high wave action, or
   - very high (> 26 ppt/yr) salinity fluctuations.

4. Comparisons between sites are made based on the value of the final score.

Table B2. Scoring of estuarine metric criteria.

Salinity[1]	Points	Estuarine BI	Total S	Total S amphipods & caridean shrimp
Polyhaline	1	> 2.6	≥ 95	≥ 21
	2	2.5 - 2.59	86 - 94	18 - 20
	3	2.01 - 2.49	69 - 85	13 - 17
	4	1.91 - 2.0	60 - 68	10 - 12
	5	≤ 1.9	< 60	< 9
Mesohaline	1	> 2.2	≥ 38	≥ 8
	2	2 - 2.16	32 – 37	7
	3	1.96 - 2.15	24 – 31	6
	4	1.9 - 1.95	18 – 23	4 or 5
	5	< 1.9	< 17	< 3

[1]**Polyhaline = 21 ppt to seawater, mesohaline = 10 – 20 ppt.**

References

Chutter, F. M. 1972. An empirical biotic index of the quality of water in South African streams and rivers. Water Research. 6: 19-30.

Eaton, L. E. (in press). Development and validation of biocriteria using benthic macroinvertebrates for North Carolina estuarine waters. Marine Pollution Bulletin.

Hilsenhoff, W. L. 1977. Use of arthropods to evaluate water quality in streams. Wisconsin Department of Natural Resources, Technical Bulletin No. 100.

Lenat, D. L. 1993. A biotic index for the southeastern United States: derivation and list of tolerance values, with criteria for assigning water-quality ratings. J. North American Benthological Society. 12: 279-290.

Flow Measurement

Changes in the benthic macroinvertebrate community are often used to help assess between-year changes in water quality. Some between-year changes in the macroinvertebrates, however, may be due largely to changes in flow. High flow years magnify the potential effects of nonpoint source runoff, leading to scour, substrate instability, and reduced periphyton. Low flow years may accentuate the effect of point source dischargers by providing less dilution of wastes.

For these reasons, all between-year changes in the biological communities are considered in light of flow conditions (high, low, or normal) for one month prior to the sampling date. Daily flow information is obtained from the closest available USGS monitoring site and compared to the long-term mean flows. High flow is defined as a mean flow > 140% of the long-term mean for that time period, usually July or August. Low flow is defined as a mean flow < 60% of the long-term mean, while normal flow is 60-140% of the mean. While broad scale regional patterns are often observed, there may be large geographical variation within the state, and large variation within a single summer period.

Habitat Evaluation

The Division has developed a habitat assessment form to better evaluate the physical habitat of a stream. The habitat score has a potential range of 1 - 100, based on evaluation of channel modification, amount of instream habitat, type of bottom substrate, pool variety, bank stability, light penetration, and riparian zone width. Higher numbers suggest better habitat quality, but no criteria have been developed to assign impairment ratings.

Appendix B2. Benthic macroinvertebrate data collected in the White Oak River basin, 1983 - 1999. Current basinwide monitoring sites have the Map No. bolded.

Subbasin/site	Location	County	Map No.	Index No.	Date	S/EPT S (S/A & C S)[1]	BI/BI EPT (E BI)[1]	Bio Class/ Final score[1]
01								
Freshwater								
White Oak R	US 17	Jones	**B-2**	20-(1)	7/99	70/15	7.07/6.16	G-F
					2/99	61/11	7.11/5.83	NR
White Oak R	Haywoods Landing	Jones	B-3	20-(1)	8/94	36/4	8.77/4.31	F
					6/86	49/5	7.87/5.83	F
					7/84	58/8	7.80/7.04	G-F
Starkeys Cr	SR 1434	Onslow	**B-11**	20-10	2/99	93/15	7.28/5.66	NR-22
Holston Cr	NC 58	Jones	**B-12**	20-12	11/99	-/13	-/4.99	NR
					2/99	58/17	6.26/4.44	NR-30
					3/98	50/15	5.85/4.92	NR-30
Hunters Cr	SR 1100	Carteret	**B-13**	20-17	2/99	56/11	6.80/6.04	NR-28
Webb Cr	SR 1432	Onslow	**B-14**	20-19	2/99	30/3	7.34/4.06	NR-10
Pettiford Cr	USFS Rd	Carteret	B-15	20-29-1	2/99	38/10	6.38/4.71	NR-30
					3/98	30/8	6.39/5.45	NR-30
Estuarine								
Queen Cr	At mouth	Onslow	B-1	19-41-16	8/94	103/17	2.26	NR-11
White Oak R	Holland Pt	Onslow	B-4	20-(14.5)	2/96	32/2	1.72	NR-8
White Oak R	Cahoon Pt	Onslow	B-5	20-(14.5)	2/96	65/9	1.65	NR-11
White Oak R	Robinson Pt	Onslow	B-6	20-(14.5)	2/96	69/8	1.98	NR-8
White Oak R	North of Jones Isl	Onslow	B-7	20-(14.5)	2/96	88/15	2.40	NR-10
White Oak R	Above Swansboro	Carteret	B-8	20-(18)	9/94	65/12	2.03	NR-9
White Oak R	Near Swansboro	Carteret	**B-9**	20-(18)	6/99	145/26	2.66	NR-15
					2/96	111/16	2.23	NR-11
White Oak R	Near Huggins Isl	Onslow	B-10	20-(18)	2/96	137/23	2.48	NR-13
Fosters Cr	Off outfall	Onslow	B-16	20-35	8/94	64/14	2.68	NR-12
02								
Freshwater								
New R	NC 24	Onslow	B-1	19-(1)	7/95	-/10	-/5.90	F
New R	SR 1314	Onslow	**B-2**	19-(1)	7/99	53/11	6.40/6.08	G-F
					7/95	74/12	6.63/6.05	G-F
					8/94	52/3	7.18/5.27	NR
					6/90	70/15	6.43/5.13	G-F
					7/88	88/24	6.04/4.19	G
					6/86	84/24	6.16/4.97	G
					7/85	96/24	6.19/4.61	G
					7/84	92/25	6.19/4.76	G
					7/83	83/20	6.32/5.28	G-F
Blue Cr	Above Blue Cr Utility	Onslow	B-15	19-8	2/97	40/6	6.89/5.76	F
Blue Cr	Below Blue Cr Utility	Onslow	B-16	19-8	2/97	53/7	7.57/5.40	F
Northeast Cr	SR 1434	Onslow	**B-17**	19-16-(0.5)	2/99	62/10	6.97/5.20	NR-22
L Northeast Cr	SR 1423	Onslow	**B-18**	19-16-2	2/99	62/15	6.60/5.48	NR-30
Harris Cr	SR 1109	Onslow	**B-19**	19-17-3	2/99	63/13	7.13/5.70	NR-26
Southwest Cr	SR 1213	Onslow	**B-20**	19-17-(0.5)	2/99	69/11	7.54/5.98	NR-22
Southwest Cr	SR 1105	Onslow	B-21	19-17-(6.5)	8/94	59/5	7.04/6.57	F
Wallace Cr	Above NC 24	Onslow	B-22	19-20	5/95	37/2	7.70/5.67	NR
UT Wallace Cr	Below Pinet Green	Onslow	B-23	19-20	5/95	15/0	9.16/-	NR
NW Mill Cr	Upstream NC 210	Onslow	B-24	19-39-3-1	8/85	58/5	7.49/5.18	NR
					2/84	43/5	7.11/5.98	NR
NW Mill Cr	Downstream NC 210	Onslow	B-25	19-39-3-1	8/85	44/2	7.57/3.22	NR
					2/84	22/3	6.35/5.93	NR
NE Mill Cr	Near confluence	Onslow	B-26	19-39-3-1	8/85	49/1	7.81/6.37	NR
N Mill Cr	Near confluence	Onslow	B-27	19-39-3-1	8/85	26/2	7.40/5.84	NR
E Mill Cr	Below confluence	Onslow	B-28	19-39-3-1	8/85	34/0	7/83/-	NR
					2/84	36/2	7.50/3.53	NR
Estuarine								
New R	Near Ethridge Pt	Onslow	B-3	19-(11)	8/94	11/-	1.0*	NR
Brinson Cr	At mouth	Onslow	B-4	19-(12)	8/94	7/-	1.0*	NR
Wilson Bay	At outfall	Onslow	B-5	19-(14)	6/99	15/1	1.67	NR
					5/97	2/0	1.00	NR
					6/96	2/0	1.00	NR

Appendix B2 (continued).

Subbasin/site	Location	County	Map No.	Index No.	Date	S/EPT S (S/A & C S)[1]	BI/BI EPT (E BI)[1]	Bio Class/ Final score[1]
Wilson Bay	Off point	Onslow	B-6	19-(14)	6/99	9/0	1.70	NR
					5/97	9/0	1.12	NR
					6/96	4/0	1.00	NR
					8/94	2/-	1.0*	NR
Wilson Bay	In center	Onslow	B-7	19-(14)	6/99	10/2	1.34	NR
					5/97	5/0	1.02	NR
					6/96	4/0	1.00	NR
Wilson Bay	South side	Onslow	B-8	19-(14)	6/99	9/2	1.16	NR
					5/97	14/1	1.38	NR
					6/96	11/0	1.35	NR
New R	Off Spring Pt		B-9	19-(15.5)	6/99	34/7	1.77	NR-7
					5/97	26/6	1.54	NR-9
					6/96	26/5	1.98	NR-9
					8/94	19/1	2.47	NR-8
New R	Near Hadnot WWTP	Onslow	B-10	19-(15.5)	6/99	35/8	1.73	NR-6
					5/97	25/5	1.93	NR-8
					6/96	30/5	2.11	NR-9
					8/94	21/1	2.12	NR-6
New R	Stones Bay WWTP	Onslow	B-11	19-(15.5)	6/96	22/3	1.88	NR-6
New R	Stones Bay	Onslow	B-12	19-(15.5)	6/96	23/2	1.76	NR-6
New R	Near Courthouse Bay	Onslow	B-13	19-(15.5)	6/96	65/12	2.47	NR-7
New R	Near Hall Pt	Onslow	B-14	19-(15.5)	6/96	76/15	2.29	NR-8
New R (ICWW)	Near Sneads Ferry	Onslow	**B-29**	19-41-(0.5)	7/99	141/29	2.71	NR-15
					11/96	103/16	2.35	NR-11
					6/96	161/26	2.66	NR-15
					8/94	153/29	2.48	NR-13
					6/93	92/19	2.50	NR-14
					6/90	81/17	2.63	NR
					6/89	71/12	2.22	NR
					7/88	66/13	2.60	NR
					6/87	67/11	2.59	NR
					6/86	65/13	2.64	NR
					7/85	70/10	2.36	NR
					7/83	37/4	2.37	NR
03								
Freshwater								
NW Pr Newport R	SR 1206	Carteret	**B-2**	21-2	2/99	40/6	6.53/3.34	NR-26
SW Pr Newport R	Fire Service Rd,	Carteret	B-3	21-3	3/98	16/2	6.82/6.27	NR-26
SW Pr Newport R	SR 1124	Carteret	**B-4**	21-3	2/99	38/10	6.54/4.66	NR-26
Newport R	US-70	Carteret	B-5	21-(1)	7/83	24/2	7.82/5.70	NR
Estuarine								
Bogue Sound	Near Emerald Isle	Carteret	**B-1**	20-36-(0.5)	6/99	112/23	2.72	NR-15
					11/96	116/21	2.80	NR-15
					11/96	132/26	2.82	NR-15
					11/96	116/22	2.81	NR-15
					9/94	131/27	2.80	NR-15
					6/94	125/26	2.72	NR-15
					6/91	121/22	2.61	NR-15
					6/90	95/19	2.59	NR
					6/89	97/15	2.59	NR
					6/88	80/14	2.60	NR
					6/87	67/9	2.75	NR
					6/86	81/14	2.72	NR
					7/85	82/12	2.71	NR
					7/84	67/9	2.62	NR
					7/83	59/10	2.74	NR

Appendix B2 (continued).

Subbasin/site	Location	County	Map No.	Index No.	Date	S/EPT S (S/A & C S)[1]	BI/BI EPT (E BI)[1]	Bio Class/ Final score[1]
Newport R	Near Crab Pt	Carteret	**B-6**	21-(17)	6/99	129/20	2.33	NR-12
					8/94	102/12	2.42	NR-10
					6/91	94/15	2.14	NR
					6/90	48/9	2.22	NR
					6/88	76/12	2.46	NR
					7/87	67/10	2.29	NR
					6/86	52/6	2.17	NR
					7/85	44/6	2.22	NR
Morehead Harbor	SW of Radio Is	Carteret	**B-7**	21-(17)	7/99	161/33	2.86	NR-15
					8/94	105/22	2.62	NR-15
					6/94	132/31	2.97	NR-15
					6/91	116/30	2.72	NR
					6/90	77/18	2.44	NR
					6/88	111/16	2.47	NR
					6/86	72/12	2.70	NR
					7/85	73/10	2.73	NR
Beaufort Inlet	Ft Macon jetty	Carteret	B-8	21-(17)	6/94	32/10	3.48	NR-10
Willis Cr	at point	Carteret	B-9	21-29	7/99	105/14	2.16	NR-11
Calico Cr	Piggotts Br	Carteret	B-10	21-32	7/99	37/6	1.69	NR-3
					8/94	22/2	1.76	NR-3
Calico Cr	at mouth	Carteret	B-11	21-32	7/99	53/4	1.91	NR-4
Taylors Cr	Rachel Carson Re	Carteret	B-12	21-34	6/88	65/10	2.23	NR
04								
Taylors Cr	W of Beaufort WWTP	Carteret	B-1	21-34	9/94	19/0	2.9*	NR
Taylors Cr	E of Beaufort WWTP	Carteret	B-2	21-34	9/94	11/1	3.4*	NR
North R	US-70	Carteret	B-3	21-35-1	8/94	55/6	2.27	NR-7
North R	At mouth	Carteret	B-4	21-35-1	8/94	99/25	2.84	NR-15
Ward Cr	US 70	Carteret	B-5	21-35-1-7	8/94	35/6	2.10	NR-6
					7/85	40/9	2.32	NR
Back Sound	Marker 3	Carteret	B-6	21-35-(1.5)	8/94	118/22	2.59	NR-15
Nelson Bay	Marker 1	Carteret	B-7	21-35-7-10-(5)	8/94	77/20	2.84	NR-12
Jarrett Bay	Midden Pt	Carteret	B-8	21-35-7-22	8/94	87/26	2.95	NR-13
05								
Back Sound	Marker 30	Carteret	B-1	21-35-(1.5)	8/94	100/26	2.90	NR-15
Core Sound	Goose Isl	Carteret	B-2	21-35-7	8/94	105/22	2.83	NR-15
Core Sound	Marker 25	Carteret	B-3	21-35-7	8/94	101/28	2.91	NR-15

[1]Abbreviations
S = Number of taxa
EPT S = Number of EPT taxa
A & C S = Number of species of amphipods and caridean shrimps
BI = Biotic Index
BI EPT = Biotic Index of EPT taxa
E BI = Estuarine Biotic Index
G = Good
G-F = Good-Fair
NR = not rated

*These samples were collected using a petite Ponar dredge and thus should not be compared with samples collected by sweep.

Appendix FT1. Fish tissue criteria.

In evaluating fish tissue analysis results, several different types of criteria are used. Human health concerns related to fish consumption are screened by comparing results with federal Food and Drug Administration (FDA) action levels (USFDA 1980), Environmental Protection Agency (USEPA) recommended screening values, and criteria adopted by the North Carolina State Health Director (Table FT1). Individual parameter results which appear to be of potential human health concern are evaluated by the N.C. Division of Occupational and Environmental Epidemiology by request from the Water Quality Section.

The FDA levels were developed to protect humans from the chronic effects of toxic substances consumed in foodstuffs and thus employ a "safe level" approach to fish tissue consumption. Presently, the FDA has only developed metals criteria for mercury.

The US EPA has recommended screening values for target analytes which are formulated from a risk assessment procedure (USEPA 1995). These are the concentrations of analytes in edible fish tissue that are of potential public health concern. The DWQ compares fish tissue results with US EPA screening values to evaluate the need for further intensive site specific monitoring.

The North Carolina State Health Director has adopted a selenium limit of 5 µg/g for issuing an advisory. Although the USEPA has suggested a screening value of 0.7 ppt (pg/g) for dioxins, the State of North Carolina currently uses a value of 3.0 ppt in issuing an advisory.

Table FT1. Fish tissue criteria. All wet weight concentrations are reported in parts per million (ppm, µg/g), except for dioxin which is in parts per trillion (ppt, pg/g).

Contaminant	FDA Action Levels	US EPA Screening Values	NC Health Director
Metals			
Cadmium		10.0	
Mercury	1.0	0.6	1.0
Selenium		50.0	5.0
Organics			
Aldrin	0.3		
Chlorpyrifos		30	
Total chlordane		0.08	
Cis-chlordane	0.3		
Trans-chlordane	0.3		
Total DDT[1]		0.3	
o,p DDD	5.0		
p, p DDD	5.0		
o,p DDE	5.0		
p,p DDE	5.0		
o,p DDT	5.0		
p,p DDT	5.0		
Dieldrin		0.007	
Dioxins (total)		0.7	3.0
Endosulfan (I and II)		60.0	
Endrin	0.3	3.0	
Heptachlorepoxide		0.01	
Hexachlorobenzene		0.07	
Lindane		0.08	
Mirex		2.0	
Total PCBs		0.01	
PCB-1254	2.0		
Toxaphene		0.1	

[1] Total DDT includes the sum of all its isomers and metabolites (i.e. p,p DDT, o,p DDT, DDE, and DDD).
[2] Total chlordane includes the sum of cis-and trans- isomers as well as nonachlor and oxychlordane.

Appendix FT2. **Wet weight concentrations of mercury (Hg), arsenic (As), cadmium (Cd), and total chromium (Crt) in fish tissue from the White Oak River basin, 1994 - 1999.**

Site	County	Date	Species	Length (cm)	Weight (g)	Hg (ug/g)	As (ug/g)	Cd (ug/g)	Crt (ug/g)
Brinson Creek	Onslow	04/01/98	*Amia calva*	55.3	1562	0.29	ND	ND	ND
			Amia calva	60.8	2300	0.25	ND	ND	ND
			Lepomis gibbosus	9.95	20.5	0.04	ND	ND	ND
			Lepomis gibbosus	15.2	93	0.08	ND	ND	ND
			Lepomis gibbosus	16	98	0.10	ND	ND	ND
			Micropterus salmoides	30	417	0.26	ND	ND	ND
			Micropterus salmoides	31.5	598	0.12	ND	ND	ND
			Micropterus salmoides	32.5	465	0.31	ND	ND	ND
			Micropterus salmoides	33	589	0.16	ND	ND	ND
			Micropterus salmoides	33.7	579	0.14	ND	ND	ND
			Micropterus salmoides	34.5	520	0.92	ND	ND	ND
			Micropterus salmoides	34.5	605	0.25	ND	ND	ND
			Micropterus salmoides	34.5	695	0.28	ND	ND	ND
			Micropterus salmoides	36	666	0.25	ND	ND	ND
			Micropterus salmoides	36	677	0.27	ND	ND	ND
			Micropterus salmoides	36.7	733	0.34	ND	ND	ND
			Micropterus salmoides	36.7	734	0.27	ND	ND	ND
			Micropterus salmoides	37.5	878	0.32	ND	ND	ND
			Micropterus salmoides	38.8	1036	0.30	ND	ND	ND
			Micropterus salmoides	40	875	0.32	ND	ND	ND
			Micropterus salmoides	41.2	1275	0.30	ND	ND	ND
New River above Jacksonville	Onslow	07/16/97	*Ameiurus catus*	29.8	366.5	0.12	ND	ND	ND
			Amia calva	44.2	839	0.16			
			Amia calva	47.7	1020	0.24			
			Amia calva	48.4	1097	0.30	ND	ND	ND
			Amia calva	52.8	1425	0.32			
			Amia calva	53.8	1713	0.19			
			Amia calva	54.8	1647	0.31	ND	ND	ND
			Amia calva	55.7	1847	0.43	ND	ND	ND
			Lepomis auritus	18.7	121	0.08	ND	ND	ND
			Lepomis auritus	20.5	274	0.07	ND	ND	ND
			Lepomis auritus	23	245	0.15			
			Lepomis auritus	24	285	0.10			
			Lepomis auritus	25.4	358	0.36	ND	ND	ND
			Lepomis gibbosus	13.3	55.5	0.24			
			Lepomis gibbosus	15.8	91.5	0.08			
			Lepomis gibbosus	16.2	96	0.08			
			Lepomis gibbosus	18	129	0.15	ND	ND	ND
			Lepomis macrochirus	19.3	189	0.09	ND	ND	ND
			Lepomis macrochirus	21.1	228	0.18			
			Lepomis macrochirus	21.5	267	0.15	ND	ND	ND
			Lepomis macrochirus	21.7	281	0.20			
			Lepomis macrochirus	21.8	264	0.16	ND	ND	ND
			Lepomis macrochirus	22	265	0.28			
			Lepomis macrochirus	23.2	326	0.24			
			Micropterus salmoides	26.5	240	0.19	ND	ND	ND
			Micropterus salmoides	27.8	334	0.22			
			Micropterus salmoides	29	361	0.16	ND	ND	ND
			Micropterus salmoides	33.2	514	0.23			
			Micropterus salmoides	33.7	559	0.25			
			Micropterus salmoides	36.9	703	0.30	ND	ND	ND

Appendix FT2. (continued).

Site	County	Date	Species	Length (cm)	Weight (g)	Hg (ug/g)	As (ug/g)	Cd (ug/g)	Crt (ug/g)
Northeast Creek above NC 24	Onslow	04/01/98	*Lepomis gibbosus*	13.7	59.6	0.12	ND	ND	0.39
			Lepomis gibbosus	14.9	84.3	0.09	ND	ND	0.35
			Lepomis gibbosus	15.9	98.3	0.09	ND	ND	ND
			Lepomis microlophus	17.8	142.5	0.10	ND	ND	ND
			Lepomis microlophus	20	172	0.06	ND	ND	ND
			Lepomis microlophus	21	215	0.23	ND	ND	ND
			Lepomis microlophus	22	224	0.27	ND	ND	ND
			Lepomis microlophus	24.2	309	0.27	ND	ND	ND
			Lepomis microlophus	25	362	0.27	ND	ND	ND
			Micropterus salmoides	26.1	247	0.91	ND	ND	ND
			Micropterus salmoides	27.6	317	0.20	ND	ND	ND
			Micropterus salmoides	28.4	326	0.21	ND	ND	ND
			Micropterus salmoides	28.6	336	0.27	ND	ND	ND
			Micropterus salmoides	33.1	555	0.28	ND	ND	0.41
			Micropterus salmoides	33.5	530	0.50	ND	ND	ND
			Micropterus salmoides	37.8	833	0.71	ND	ND	ND
			Micropterus salmoides	38.5	1004	0.30	ND	ND	ND
			Micropterus salmoides	40.5	1175	0.34	ND	ND	ND
			Micropterus salmoides	42.5	1435	0.45	ND	ND	ND

ND = non detect. Detection levels were 1 ug/g for arsenic, 0.1 ug/g for cadmium, and 0.25 ug/g for chromium (total).

Appendix FT3. Wet weight concentrations of copper (Cu), nickel (Ni), lead (Pb), and zinc (Zn) in fish tissue from the White Oak River basin, 1994 - 1999.

Site	County	Date	Species	Length (cm)	Weight (g)	Cu (ug/g)	Ni (ug/g)	Pb (ug/g)	Zn (ug/g)
Brinson Creek	Onslow	04/01/98	*Amia calva*	55.3	1562	0.21	ND	ND	3.6
			Amia calva	60.8	2300	0.24	ND	ND	4.6
			Lepomis gibbosus	9.95	20.5	0.59	ND	ND	21.0
			Lepomis gibbosus	15.2	93	0.26	ND	ND	6.0
			Lepomis gibbosus	16	98	0.47	0.57	ND	11.0
			Micropterus salmoides	30	417	0.35	ND	ND	3.6
			Micropterus salmoides	31.5	598	0.22	ND	ND	3.2
			Micropterus salmoides	32.5	465	0.25	ND	ND	3.6
			Micropterus salmoides	33	589	0.26	ND	ND	3.9
			Micropterus salmoides	33.7	579	0.24	ND	ND	3.7
			Micropterus salmoides	34.5	520	0.19	ND	ND	3.2
			Micropterus salmoides	34.5	605	0.25	ND	ND	4.0
			Micropterus salmoides	34.5	695	0.24	ND	ND	3.9
			Micropterus salmoides	36	666	0.27	ND	ND	4.0
			Micropterus salmoides	36	677	0.26	ND	ND	4.2
			Micropterus salmoides	36.7	733	0.19	ND	ND	3.2
			Micropterus salmoides	36.7	734	0.30	ND	ND	5.0
			Micropterus salmoides	37.5	878	0.20	ND	ND	3.6
			Micropterus salmoides	38.8	1036	0.28	ND	ND	4.2
			Micropterus salmoides	40	875	0.25	ND	ND	4.1
			Micropterus salmoides	41.2	1275	0.21	ND	ND	3.4
New River above Jacksonville	Onslow	07/16/97	*Ameiurus catus*	29.8	366.5	0.19	ND	ND	2.7
			Amia calva	44.2	839				
			Amia calva	47.7	1020				
			Amia calva	48.4	1097	0.13	ND	ND	3.7
			Amia calva	52.8	1425				
			Amia calva	53.8	1713				
			Amia calva	54.8	1647	0.15	ND	ND	3.8
			Amia calva	55.7	1847	0.19	ND	ND	4.0
			Lepomis auritus	18.7	121	0.32	ND	ND	15
			Lepomis auritus	20.5	274	0.21	ND	ND	15
			Lepomis auritus	23	245				
			Lepomis auritus	24	285				
			Lepomis auritus	25.4	358	0.28	ND	ND	20
			Lepomis gibbosus	13.3	55.5				
			Lepomis gibbosus	15.8	91.5				
			Lepomis gibbosus	16.2	96				
			Lepomis gibbosus	18	129	0.15	ND	ND	12
			Lepomis macrochirus	19.3	189	0.15	ND	ND	11
			Lepomis macrochirus	21.1	228				
			Lepomis macrochirus	21.5	267	0.56	ND	ND	15
			Lepomis macrochirus	21.7	281				
			Lepomis macrochirus	21.8	264	0.33	ND	ND	21
			Lepomis macrochirus	22	265				
			Lepomis macrochirus	23.2	326				
			Micropterus salmoides	26.5	240	0.12	ND	ND	6.4
			Micropterus salmoides	27.8	334				
			Micropterus salmoides	29	361	0.15	ND	ND	3.9
			Micropterus salmoides	33.2	514				
			Micropterus salmoides	33.7	559				
			Micropterus salmoides	36.9	703	0.14	ND	ND	5.1

Appendix FT3. (continued).

Site	County	Date	Species	Length (cm)	Weight (g)	Cu (ug/g)	Ni (ug/g)	Pb (ug/g)	Zn (ug/g)
Northeast Creek above NC-24	Onslow	04/01/98	*Lepomis gibbosus*	13.7	59.6	0.32	ND	ND	18.0
			Lepomis gibbosus	14.9	84.3	0.41	ND	ND	18.0
			Lepomis gibbosus	15.9	98.3	0.29	ND	ND	6.7
			Lepomis microlophus	17.8	142.5	0.16	ND	ND	5.3
			Lepomis microlophus	20	172	0.18	ND	ND	7.7
			Lepomis microlophus	21	215	0.14	ND	ND	4.8
			Lepomis microlophus	22	224	0.15	ND	ND	4.5
			Lepomis microlophus	24.2	309	0.16	ND	ND	4.6
			Lepomis microlophus	25	362	0.15	ND	ND	4.6
			Micropterus salmoides	26.1	247	0.20	ND	ND	3.2
			Micropterus salmoides	27.6	317	0.25	ND	ND	3.8
			Micropterus salmoides	28.4	326	0.17	ND	ND	3.3
			Micropterus salmoides	28.6	336	0.23	ND	ND	2.9
			Micropterus salmoides	33.1	555	0.18	ND	ND	2.9
			Micropterus salmoides	33.5	530	0.15	ND	ND	3.0
			Micropterus salmoides	37.8	833	0.19	ND	ND	3.1
			Micropterus salmoides	38.5	1004	0.22	ND	ND	3.1
			Micropterus salmoides	40.5	1175	0.18	ND	ND	2.8
			Micropterus salmoides	42.5	1435	0.16	ND	ND	2.7

ND = non detect. Detection levels were 0.50 ug/g for nickel and lead.

Appendix P1. Summary of samples collected in Subbasin 02 of the White Oak River basin during 1994 - 1999 and suspected as algal blooms.

Subbasin/ Waterbody/ Station	Date	Chl *a* (µg/l)	Biovolume (mm^3/ml)	Density (units/ml)	Dominant Algae[1]	Concurrent Fish kill?	Pfiesteria likes? (cells/ml)
02							
New River							
P4400000	02/08/1994	27	11103	86676	BAC		
P1200000	05/12/1994	120	32802	225077	BAC,DIN		
P1200000	06/21/1994	23	34185	41066	BAC,DIN		
P2113000	06/21/1994	62	50410	358760	BAC,DIN		
NR3	08/10/1994	9	910	1643	NQ	yes	
NR2	09/06/1994	7	16	285	NQ	yes	
New River							
P1200000	04/19/1995	65	40430	77239	BAC,CRY,DIN		
CM 57	07/12/1995	200	11388	230319	BAC,DIN		
P4100000	07/12/1995	11	8775	155526	BAC,DIN		
P2113000	07/13/1995	26	17982	218786	BAC,DIN		
P3700000	12/06/1995	120	28426	24814	CRY,DIN		
P4400000	12/06/1995	130	28020	12582	DIN		
Parker Pond							
Parker Pond	09/14/1995	170	NQ		EUG		
New River							
P1200000	04/15/1996	65	1300	40367	BAC,DIN		
P1200000	05/20/1996	180	11771	131936	BAC		
P4400000	07/18/1996	44	2929	104849	BAC,DIN	yes	698
P4700000	07/22/1996	73	4610	60987	BAC,DIN		175
P4400000	07/22/1996	240	27147	202010	BAC,CHM	prior	175
P3700000	09/01/1996	95	5693	7934	DIN,BAC	yes	350
P4100000	09/01/1996	110	9799	21844	DIN,BAC	yes	
P4100000	09/01/1996	190	12509	41503	DIN,BAC	yes	262
P3700000	09/02/1996	95	46443	6640	DIN,BAC	yes	116
P3700000	09/02/1996	95	15456	19659	DIN	yes	87
P2113000	09/02/1996	260	37236	35532	DIN,BAC	yes	
P4750000	10/07/1996	4	1223	629	NQ		
P4750000	10/16/1996	12	1892	74443	BAC		
CM 33	10/21/1996	25	5782	144168	BAC	prior	
P4700000	10/21/1996	150	16379	148886	BAC,DIN	prior	
New River							
P1200000	04/07/1997	70	5610	52949	BAC,DIN		
P3700000	04/07/1997	43	4653	19863	BAC,DIN		
P1200000	05/15/1997	82	62,591	176497	BAC,DIN		
P3700000	06/11/1997	31	74,821	30,197	DIN, CRY, BAC		
P4000000	06/11/1997	17	4709	33,901	DIN, CRY, BAC		
Jacks Point	06/11/1997	13	16,267	49,279	DIN,BAC		
P2113000	06/11/1997	18	4709	109742	DIN,BAC,CYA		
P1200000	06/25/1997	29	37,404	56,269	DIN,BAC,CYA		
Jacks Point	06/25/1997	38	6,000	121,276	DIN,BAC,CYA		
P2113000	06/25/1997	60	14850	409612	DIN,BAC,CYA		
P1200000	07/09/1997	11	33597	314548	BAC,DIN		
P3700000	07/09/1997	38	NQ	NQ	only Pf-like count		
P4000000	07/09/1997	12	21881	67453	BAC,DIN		
Jacks Point	07/09/1997	28	NQ	NQ	only Pf-like count		
P3700000	07/09/1997	38	NQ	NQ	only Pf-like count		
P2113000	07/09/1997	30	10108	98558	BAC,DIN		
Jacks Point	08/07/1997	54	13208	339363	BAC,DIN		
P2113000	08/07/1997	28	17001	706685	BAC		
P4000000	10/01/1997	9	6205	86326	BAC,DIN		
P4750000	10/03/1997	7	NQ	NQ	only Pf-like count	sores	< 12
P2113000	10/27/1997	41	7954	202,708	BAC,CYA		
P2113000	10/30/1997	22	22838	50,851	CRY,DIN		
P4000000	11/18/1997	44	18,137	36,930	CRY,BAC,DIN		
P2113000	11/18/1997	22	74,675	127,567	CRY,DIN		
P2113000	12/18/1997	160	160,621	269,812	CRY,DIN		
P1200000	12/18/1997	10	6,560	54,129	CRY		
P3700000	12/18/1997	270	59,714	134,557	CRY		
P2105000	12/18/1997	57	93,532	181319	CRY		
P4075000	12/18/1997	32	108141	28029	CRY,DIN		

Appendix P1. (continued).

Subbasin/ Waterbody/ Station	Date	Chl *a* (µg/l)	Biovolume (mm^3/ml)	Density (units/ml)	Dominant Algae[1]	Concurrent Fish kill?	Pfiesteria likes? (cells/ml)
Queens Creek							
Queens-1	07/16/1997	8	NQ	NQ	only Pf-like count		
Queens-2	07/16/1997	14	NQ	NQ	only Pf-like count	sores upstream	163
Queens-3	07/16/1997	9	NQ	NQ	only Pf-like count		
White Oak River							
White Oak-1	09/29/1997	10	NQ	NQ	only Pf-like count	sores	58
White Oak-100	10/01/1997	NS	NQ	NQ	only Pf-like count	sores	
New River							
P3100000-1	07/22/1998	820	NQ	NQ	CHR		
P3100000-4	07/22/1998	57	NQ	NQ	CHR,CRY		
P2113000	08/24/1998	10	4380	35824	CYA,CHR		
P2210000	08/24/1998	11	5589	61162	CYA,CHR,DIN		
P3700000	08/24/1998	10	2037	32678	CYA,CHR		
P4075000	08/24/1998	14	6891	66405	CYA,CHR		
P4100000	08/24/1998	190	39520	51376	CHR,CYA		
P4600000	08/24/1998	<1	4151	32503	BAC,CHR,CYA		
P2113000	09/15/1998	46	14647	105898	CHR,CRY		
P3700000	09/15/1998	27	14334	51376	CHR,CRY,CHL,EUG		
P4000000	09/15/1998	17	20089	59065	CHR,CRY,CHL		
P4075000	09/15/1998	250	53906	723466	CHR		
P4200000	09/15/1998	15	52591	118829	CHL,CHR		
P4400000	09/15/1998	17	59582	131411	CHL,CHR		
P4570000	09/15/1998	29	6397	85627	CHL,CHR		
P4600000	09/15/1998	39	7698	67803	CHR		
P4700000	09/15/1998	29	11870	11300	CHR		
P4600000	09/29/1998	16	1913	37979	CHR,CHL	yes	64
P4700000	09/29/1998	25	3258	49803	CHR,CHL	yes	23
P3	09/29/1998	NS	NQ	NQ	only Pf-like count	yes	29
MCAS	10/04/1998	NS	NQ	NQ	only Pf-like count	yes	0-6
P1200000	10/04/1998	NS	NQ	NQ	only Pf-like count	yes	0-6
Furnell Bay	10/05/1998	NS	NQ	NQ	only Pf-like count	yes	35
CM 35	10/05/1998	NS	NQ	NQ	only Pf-like count	yes	29
P4400000	10/05/1998	NS	NQ	NQ	only Pf-like count	yes	12
P3700000	10/05/1998	NS	NQ	NQ	only Pf-like count	yes	0
P2113000	10/05/1998	NS	NQ	NQ	only Pf-like count	yes	6
P4600000	10/05/1998	NS	NQ	NQ	only Pf-like count	yes	35
P4200000	10/05/1998	NS	NQ	NQ	only Pf-like count	yes	29
MCAS	10/05/1998	NS	NQ	NQ	only Pf-like count	yes	6
White Oak River							
1	10/06/1998	73	NQ	NQ	only Pf-like count	sores	0
2	10/06/1998	66	NQ	NQ	only Pf-like count	sores	0
New River							
P3700000	01/27/1999	25	29125	169507	BAC,CHL		
P4200000	01/27/1999	9	9200	91918	BAC,CHL		
P1200000	03/24/1999	20	11103	34600	CHL,CHR,CRY,EUG		
P2105000	03/24/1999	42	19808	64657	EUG,CHR,CHL		
P2113000	03/24/1999	17	42628	101005	EUG,DIN,CRY		
P3700000	03/24/1999	11	2491	39319	CHL,CHR		
P4000000	03/24/1999	8	3372	23678	CHR,CHL,BAC		
P1200000	04/14/1999	27	21347	456444	CHL,CHR		
P2105000	04/14/1999	5	18195	345304	CHL,CHR		
P2113000	05/05/1999	15	10111	273391	CHL,CHR		
P2210000	05/05/1999	10	43344	190612	CHL,CHR		
P3700000	05/05/1999	8	9781	239626	CHL,CHR		
P4000000	05/05/1999	6	6493	146680	CHL,CHR		
P4075000	05/05/1999	4	7640	200777	CHL,CHR		
P4200000	05/05/1999	5	41149	106742	CHL,CHR		
P4600000	05/05/1999	4	3774	67168	CHL,CHR		
P4400000	06/02/1999	72	5351	21276	CHL,CHR		
P2105000	07/07/1999	31	8850	144865	CHR,CHL		
Morgan-1	07/26/1999	40	1791	20423	CHR,DIN	fish/crabs	512
Morgan-2	07/26/1999	8	2071	16580	CHR,DIN	fish/crabs	722
CM 52	07/27/1999	22	103	1646	CHR,DIN	yes	466
CM 52	07/28/1999	10	NQ	NQ	NQ	yes	1165

Appendix P1. (continued).

Subbasin/ Waterbody/ Station	Date	Chl *a* (µg/l)	Biovolume (mm^3/ml)	Density (units/ml)	Dominant Algae[1]	Concurrent Fish kill?	Pfiesteria likes? (cells/ml)
New River							
Blue Creek	08/11/1999	16	NQ	NQ	NQ	yes	6
P2113000	11/09/1999	200	8652	100207	CHL,CRY		
P2210000	11/09/1999	36	16947	33947	DIN		
P4000000	11/09/1999	98	3284	74429	BAC		
P4075000	11/09/1999	120	30418	50104	DIN,CHR		
P4200000	11/09/1999	34	3000	35702	BAC,DIN		
P4400000	11/09/1999	69	32081	82235	DIN,CHR		
P4570000	11/09/1999	39	2410	71888	BAC		
P4700000	11/09/1999	200	310695	58817	DIN		
P2105000	12/09/1999	130	60911	24931	DIN		
P2113000	12/09/1999	38	124008	41027	DIN		
P2210000	12/09/1999	28	84065	38969	DIN		
P4100000	12/09/1999	99	193613	62629	DIN		
Morgan Bay							
MB1	07/27/1999	24	NQ	NQ	NQ	yes (bycatch?)	1258
MB2	07/27/1999	25	NQ	NQ	NQ	yes	2178
MB3	07/27/1999	23	129	1349	DIN,CHR	yes	1887
MB1	07/28/1999	21	NQ	NQ	NQ	yes	1141
MB2	07/28/1999	16	NQ	NQ	NQ	yes	838
Wallace Creek							
WC	07/27/1999	25	NQ	NQ	NQ	yes	1951
Northeast Creek							
NEC	07/27/1999	26	NQ	NQ	NQ	yes	1904
NEC	07/28/1999	36	NQ	NQ	NQ	yes	2015
Northeast-1	08/05/1999	95	10206	46836	DIN,BAC,CHR	yes	559
Northeast-2	08/05/1999	130	14201	46654	CHR,DIN	yes	402
03							
Calico Cr							
Calico-5	06/21/1994	11	501	2929	BAC		
Beaufort Inlet							
Beaufort-1	09/18/1997	NS	NQ	NQ	only Pf-like count	net marks	105
Bogue Sound							
Boat Basin-A	09/20/1997	12	NQ	NQ	only Pf-like count	lethargic fish	
Bogue Dock-2	09/20/1997	NS	NQ	NQ	only Pf-like count	lethargic fish	
Bogue-50	10/02/1997	NS	NQ	NQ	only Pf-like count	sores	0-12
Green Pond							
Green Pond	05/19/1998	NS	NQ	NQ	DIN-Peridinium	yes; herbicides	
04							
Ward Creek							
P8976000	08/05/1997	9	NQ	NQ	NQ		
North River							
P8975000	07/29/1999	59	4817	56639	BAC,CHR		
Ward Creek							
P8976000	07/29/1999	14	1094	27261	BAC,CHR		
Broad Creek							
P8978000	11/29/1999	3	5216	34976	EUG,CRY		

[1]Abbreviations
BAC - Bacillariophyceae (diatom)
DIN - Dinophyceae (dinoflagellates)
CHL - Chlorophyceae (green algae)
EUG - Euglenophyceae (euglenoids)
CHM - Chloromonadophyceae
CRY - Cryptophyceae (cryptomonads)
CYA - Cyanophyceae (blue-green algae)
Pf-likes - Pfiesteria-like dinoflagellates
NS - not sampled
NQ - not quantified